THE

COMPLETE

SLIDE RULE INSTRUCTOR,

CONTAINING UPWARDS OF

THREE HUNDRED QUESTIONS

AND SOLUTIONS

FOR THE

IMPROVED SLIDE RULE,

ADAPTED FOR THE USE OF

ENGINEERS, MILLWRIGHTS, COTTON SPINNERS,
MECHANICS, BLACKSMITHS, MOULDERS,
AND ARTISANS IN GENERAL,

Containing a greater variety of RULES *and* QUESTIONS *upon the above subjects than has been before published in any Instruction Book for the use of the Slide Rule.*

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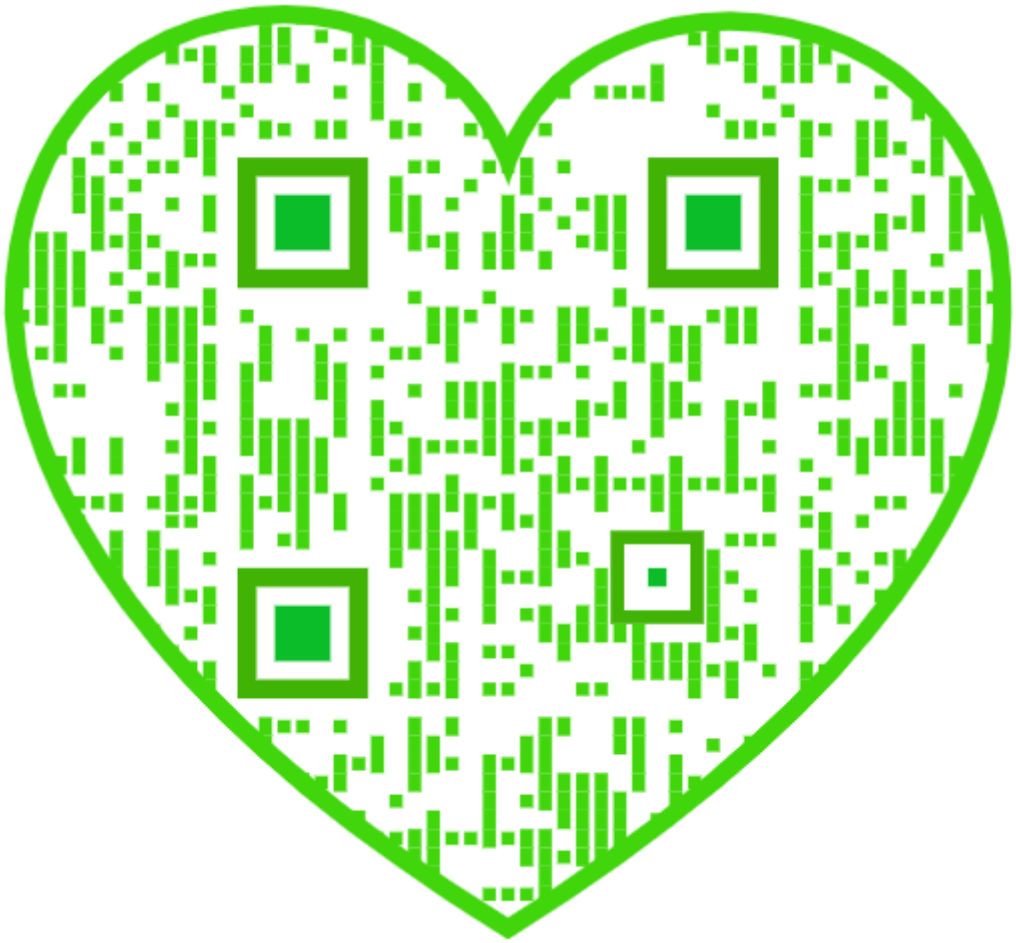

PREFACE.

g another Instruction Book, for the use of the ule, the compiler presumes that few remarks essary; because, in the first place, the books in existence contain a very small number of s, and those are of a primitive character and do sufficiently on Practice; and, secondly, many nt Rules are entirely neglected, and many Rules n without a demonstration, which is defective, nd lame; for the pupil may commit great errors absence of a demonstration. Again, when any is not fairly laid down upon a definite system, bject will never progress.

n this, it appears that some one useful book is , to bring the theory of the Slide Rule to bear decidedly on Practice; and, at the same time, ome system that is sure of success, and at a price ble to the whole community.

this little book an attempt has been made to y those evils by giving, at the head of each

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department, a comprehensive rule, one or more examples, and an easy method of solution, void of technicalities or complication, to each question throughout the entire work.

In addition to the existing Rules, a variety of Rules have been inserted on Cotton Spinning; the Weighing of Flat Metals has also been introduced; Rules applicable to the Steam Engine, Mensuration, of Polygons, Blocks, and Pulleys, and a variety of useful and practical questions, adapted to the daily business of artisans generally.

I will not dwell upon the merits of the book, nor can I boast of any literary talent; but I can say, without arrogance, that I have had considerable experience in the practical use of the Slide Rule in its various branches, and feel confident that this book will be found to contain many things new and useful. Should it prove beneficial to the pupil, my desires will be gratified. Wishing the pupil success in his labours, not doubting that he will benefit thereby, and hoping that he may, is the hearty desire of his

Humble Servant,

WILLIAM PATTEN, Jun.

ASHTON-UNDER-LYNE,
JUNE 24, 1857.

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INSTRUCTIONS,

&c.

EXPLANATION OF THE LINES.

At the plain end of the rule, about three-eighths of an inch from the end, it is marked with the first four letters of the Alphabet A, B, C, D. B, C, are upon the brass slide, and A, D, are upon the wood (which is generally good box wood.) A line runs through each letter from end to end of the rule, and is called A line, B line, C line, and D line. A, B, and C are marked exactly alike, and are composed of a double radius, and figured from left to right, from 1 to 10 twice over. The line D is a single radius, double the length of the others, and figured from 1 to 10. The lines B, C, slide between A, D, and by this operation are all the questions answered in the following work, except square root, which will be explained under that head.

Each of the figures are separated by fine lines or divisions, and are divided in the following manner:—between 1 and 2 are 50 divisions; from 2 to 3, 20 divisions; from 3 to 4, 20 divisions; from 4 to 5, from 5 to 6, from 6 to 7, from 7 to 8, from 8 to 9, from 9 to 10, each have 10 divisions; the second or right hand radius is a repetition of the first, and is divided as before. The line D is divided as follows:—from 1 to 2 are 100 divisions; from 2 to 3, 50 divisions; from 3 to 4, 50 divisions; from 4 to 5, and from 5 to 6, 20 divisions; the rest have 10 divisions each.

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NUMERATION.

NUMERATION is the art of valuing aright the lines and divisions upon the rule, for be it known that numeration is the governing rule of instrumental arithmetic, without it nothing can be done, and upon it every other rule is entirely dependant, and in order that the pupil may well understand this rule, observe the following:—

First—That all numbers and divisions are arbitrary.

Secondly—That all the numbers and divisions increase and decrease in a ten-fold proportion.

Thirdly—That the lowest numbers must be taken next the joint end of the rule, increasing towards the right hand.

If the pupil attend to the foregoing directions, he will not find any difficulty in pointing out any number upon the radius lines; they may be best understood in the following order:—if the first 1 next the joint denote 1-tenth, then the middle 1 will be 1 unit or 1 whole number, the other figures towards the right are also whole numbers, from the middle 1 to 10 at the plain end. Again, if the first 1 denote 1 unit or 1 whole number, then the middle 1 will denote 10, and the 10 at the plain end will denote 100. Again, if the first 1 denote 10, the middle 1 will be 100, and 10 at the plain end 1,000. By repeating again the 10 at the plain end will denote 10,000, &c. &c.

The divisions between the figures will in all cases change their value, thus, when the first 1 denotes 1 unit, then the next figure which is 2 will be 2 units; the divisions are parts between 1 and 2, as $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, &c. Again the middle 1 will denote 10, and the next figure 2 will be 20; the divisions are parts between 10 and 20; each long division will be 1, as 10 and 1 are 11; and 5 long divisions will be 5 and 10 is 15, and so on with any number between 10 and 20.

I will now proceed with a few examples and conclude this rule.

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1. Let it be proposed to find 13 on the upper line or line A? Commence at the joint end and say 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and count 3 long divisions towards the right hand and 10 is 13, the number required. If an higher value be put upon the first 1, this number will represent 130, 1,300, &c.

Note in pointing out any number slide 1 upon B opposite the number required upon A.

2. Point out the number 39½ upon the line A? Commence at the joint as before, and say 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, and 9 long divisions towards 4 is 9, and 1 short division is ½; altogether is 39½, the number required. This number is also 395, 3,950, 39,500, &c.

3. Find 990 upon the line A? The first 1 will be 10, the middle 1 100, the next figure which is 2 will be 200, and the next figure 300, 400, 500, 600, 700, 800, 900, and 9 divisions will be 90, when added together is 990, the number required. This number is also 99, 990, 9,900, or $9\frac{9}{10}$, &c.

4. Numerate 188 upon the line A? The first 1 will denote 10, the middle 100, and 8 long divisions is 80, and 4 short divisions is 8; when added is 188, the number required.

5. Numerate 19 shillings upon the line A? The middle 1 will be 10, and each long division is 1 shilling; count 9 long divisions towards 2 is 9 shillings, and 10 is 19 shillings, the number required. This is also £1. 18s., £190., £1,900, &c.

6. Find £2. 15s. upon the line A? The 2 next the joint will be £2., and 7 long divisions is 14s., and 1 short division is 1 shilling, which is £2. 15s. the value sought.

7. Find 3,350 upon the line A? The first 1 will denote 100, the middle 1 1,000, and the 3 towards the right hand is 3,000, and 3 long divisions is 300, and 1 short division is 50; when added is 3,350, the number sought. This is also 33½, 335, and decimally 3·35, 33·5.

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The foregoing examples being well considered are sufficient for the industrious pupil.

MULTIPLICATION.

By multiplication we increase or multiply one number by another as often as there are units in either of the numbers. This rule should be well understood by the pupil, for by it many hundreds of questions in many parts of arithmetic are resolved.

In multiplication are three principal parts to be well taken notice of:—

First—The multiplicand, or number to be multiplied.

Secondly—The multiplier, or number by which we multiply.

Thirdly—The product, or the number proceeding or produced from both.

Rule. Set the multiplier upon B to 1 or 10 upon A, and opposite any multiplicand upon A will be the product upon B.

EXAMPLES.

6. What is the product of $2\frac{1}{2}$ multiplied by 3?

Ans. $7\frac{1}{2}$.

Set 3 upon B to 1 upon A, and opposite $2\frac{1}{2}$ upon A is $7\frac{1}{2}$ upon B, the answer.

The slide thus set you have a table of products multiplied by 3, for opposite any multiplicand upon A is the product upon B, as follows:—

Multiplicands upon A, 1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, 4, 5, 6, 7.

Products upon B, 3, $4\frac{1}{2}$, 6, $7\frac{1}{2}$, 9, 12, 15, 18, 21.

And in like manner, at every operation, the lines A and B will form a set of tables.

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9. What is the product of 4 multiplied by 5?

Ans. 20.

Set 5 upon B to 1 upon A, and opposite 4 upon A is 20 upon B, the answer.

This question is the same as if one had demanded 4 yards of calico at 5d. per yard.

10. What is the product of 12 multipled by 8?

Ans. 96.

Set 8 upon B to 1 upon A, and opposite 12 upon A is 96 upon B, the answer.

11. What is the product of 14 multiplied by 7?

Ans. 98.

Set 7 upon B to 1 upon A, and opposite 14 upon A is 98 upon B, the answer.

12. What is the product of 84 multiplied by 5?

Ans. 420.

Set 5 upon B to 10 upon A, and opposite 84 upon A is 420 upon B, the answer.

13. What is the product of 18 multiplied by $6\frac{1}{2}$?

Ans. 117.

Set $6\frac{1}{2}$ upon B to 10 upon A, and opposite 18 upon A is 117 upon B, the answer.

14. What is the product of 325 multiplied by 26?

Ans. 8450.

Set 26 upon B to 10 upon A, and opposite 325 upon A is 8450 upon B, the answer.

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15. What is the product of 75 multiplied by 19?

Ans. 1425.

Set 19 upon B to 10 upon A, and opposite 75 upon A is 1425 upon B, the answer.

16. What is the product of 38 multiplied by 23?

Ans. 874.

Set 23 upon B to 10 upon A, and opposite 38 upon A is 874 upon B, the answer.

17. What is the product of 144 multiplied by 12?

Ans. 1728.

Set 12 upon B to 10 upon A, and opposite 144 upon A is 1728 upon B, the answer.

18. What cost 30 yards of cloth at 4s. 6d. per yard?

Ans. 135 shillings.

Set 4s. 6d., or $4\frac{1}{2}$, upon B to 10 upon A, and opposite 30 yards upon A is 135 shillings upon B, the answer.

19. What cost 40lbs. of coffee at 2s. 9d. per lb.?

Ans. 110 shillings.

Set 2s. 9d., or $2\frac{3}{4}$, upon B to 10 upon A, and opposite 40 upon A is 110 shillings upon B, the answer.

20. What cost 96 bags of nails at 4s. 3d. per bag?

Ans. 408 shillings.

Set 4s. 3d., or $4\frac{1}{4}$, upon B to 10 upon A, and opposite 96 upon A is 408 shillings upon B, the answer.

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21. What cost 30 tons of iron at £2. 15s. 0d. per ton?

Ans. £82 10s. 0d.

Set £2. 15s. 0d., or $2\frac{3}{4}$, upon B to 1 upon A, and opposite 30 upon A is £82. 10s 0d. upon B, the answer.

22. What cost 160 sets of china at £3. 5s. 0d. per set?

Ans. £520.

Set £3. 5s. 0d., or $3\frac{1}{4}$, upon B to 10 upon A, and opposite 160 upon A is £520 upon B, the answer.

23. What cost 75,000 bricks at £1. 4s. 0d. per 1000?

Ans. £90.

Set £1. 4s. 0d. upon B to 10 upon A, and opposite 75 upon A is 90 upon B, the answer.

24. What cost 240 umbrellas at 7s. 3d. each?

Ans. 1740 shillings.

Set 7s. 3d., or $7\frac{1}{4}$, upon B to 100 upon A, and opposite 240 upon A is 1740 shillings upon B, the answer.

Note. The operation may be contracted in the last question; by setting $7\frac{1}{4}$ upon B to 20 upon A, and opposite 240 upon A is £87 upon B, the answer.

25. What cost 280 gross of tape at 6s. 9d. per gross?

Ans. £94. 10s. 0d.

Set $6\frac{3}{4}$ upon B to 20 upon A, and opposite 280 upon A is £94. 10s. 0d. upon B, the answer.

26. What cost 144 lamps at 43s. 9d. each?

Ans. £315.

Set 43s. 9d. upon B to 20 upon A, and opposite 144 upon A is £315 upon B, the answer.

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27. What cost 400 cwt. of wrought iron at 28s. per cwt?

Ans. £560.

Set 28 upon B to 20 upon A, and opposite 400 upon A is £560 upon B, the answer.

DIVISION.

By division we discover how often one number is contained in another. In division are three principal parts to be taken. First—The dividend, or number to be divided. Secondly—The divisor, or number by which we divide. Thirdly—The quotient, or number proceeding from the other two.

Sometimes there is a fourth number, called a remainder.

Rule. Set the divisor upon B to the dividend upon A, and opposite 1 or 10 upon B will be the quotient upon A.

EXAMPLES.

28. Divide 42 by 7. Ans. 6 times.

Set 7 upon B to 42 upon A, and opposite 1 upon B is 6 times upon A, the answer.

This question is the same as if we had demanded in 42 days how many weeks?

29. Divide 72 by 12. Ans. 6 times.

Set 12 upon B to 72 upon A, and opposite 1 upon B is 6 times upon A, the answer.

This question is the same as if it had been asked in 72 pence how many shillings; answer, 6 shillings.

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30. Divide 112 by 7. Ans. 16 times.

Set 7 upon B to 112 upon A, and opposite 1 upon B is 16 times upon A, the answer.

31. Divide 99 by 11. Ans. 9 times.

Set 11 upon B to 99 upon A, and opposite 1 upon B is 9 times upon A, the answer.

32. Divide 364 by 52. Ans. 7 times.

Set 52 upon B to 364 upon A, and opposite 10 upon B is 7 times upon A, the answer.

33. Divide 1728 by 72. Ans. 24 times.

Set 72 upon B to 1728 upon A, and opposite 10 upon B is 24 upon A, the answer.

34. Divide 6900 by 150. Ans. 46.

Set 150 upon B to 6900 upon A, and opposite 10 upon B is 46 upon A, the answer.

35. Divide £7800 amongst 240 men; what is each man's share?

Ans. £32. 10s. 0d.

Set 240 upon B to £7800 upon A, and opposite 10 upon B is £32. 10s. 0d. upon A, the answer.

36. In 1890 inches how many threads of 54 inches long?

Ans. 35 threads.

Set 54 upon B to 1890 upon A, and opposite 10 upon B is 35 threads upon A, the answer.

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37. Divide 625 by 25. Ans. 25 times.

Set 25 upon B to 625 upon A, and opposite 1 upon B is 25 upon A, the answer.

38. If there are 1000 ounces in a cubical foot of water, how many lbs. of 16oz. each?

Ans. 62½lbs.

Set 16 upon B to 1000 upon A, and opposite 1 upon B is 62½lbs. upon A, the answer.

39. If 60 minutes of time are equal to 1 hour, during which time the earth passes through 15 degrees of space, how long is the earth in passing through one degree?

Ans. 4 minutes.

Set 15 upon B to 60 upon A, and opposite 1 upon B is 4 minutes upon A, the answer.

40. If a set of yarn contains 1920 hanks and weighs 6lbs., how many hanks in one pound?

Ans. 320 hanks.

Set 6 upon B to 1920 upon A, and opposite 1 upon B is 320 hanks upon A, the answer.

41. If a set of yarn contains 1480 hanks and weighs 5lbs., what are the counts of the yarn?

Ans. 296 hanks.

Set 5 upon B to 1480 hanks upon A, and opposite 1 upon B is 296 hanks upon A, the answer.

42. In 1728 inches how many feet of 12 inches long?

Ans. 144 feet.

Set 12 upon B to 1728 upon A, and opposite 1 upon B is 144 feet upon A, the answer.

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43. In 112 ounces how many lbs. of 16oz. each?

Ans. 7lbs.

Set 16 upon B to 112 upon A, and opposite 1 upon B is 7lbs. upon A, the answer.

44. In 360 barleycorns how many inches, allowing 3 to 1 inch Ans. 120 inches.

Set 3 upon B to 360 upon A, and opposite 1 upon B is 120 inches upon A, the answer.

45. Divide £3. 15s. 0d. amongst 6 men and 7 women, and give each man three times the share of a woman.

Ans. 9s. a man, 3s. a woman.

Set 25 upon B, the number of shares to 75s. upon A, and opposite 3 upon B is 9s. upon A, and opposite 1 upon B is 3s. the share of a woman, the answer upon A.

46. Divide £780 amongst 40 men, what is each man's share?

Ans. £19. 10s. 0d.

Set 40 upon B to 780 upon A, and opposite 1 upon B is £19. 10s. 0d. upon A, the answer.

47. If there are 2240lbs. in one ton, how many quarters of 28lbs. each?

Ans. 80 quarters.

Set 28 upon B to 2240lbs. upon A, and opposite 10 upon B is 80 quarters upon A, the answer.

48. If the main cylinder of a carding engine is 153 inches in circumference, how many cards 4½ inches wide will clothe the same.

Ans. 34 cards.

Set 4½ upon B to 153 upon A, and opposite 1 upon B is 34 cards upon A, the answer.

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49. If a set of yarn contains 500 hanks and weighs 4lbs., what will be the counts of the yarn?

Ans. 125 hanks.

Set 4 upon B to 500 upon A, and opposite 1 upon B is 125 hanks upon A, the answer.

50. If a piece of cloth at 5s. per yard cost £20, how many yards are in it?

Ans. 80 yards.

Reduce the £20 into shillings by multiplication, then set 5 upon B to 400 shillings upon A, and opposite 1 upon B is 80 yards upon A, the answer.

51. If a wheel is 144 inches in circumference, how many teeth of 2 inches pitch are contained in the wheel?

Ans. 72 teeth.

Set 2 upon B to 144 upon A, and opposite 1 upon B is 72 teeth upon A, the answer.

RULE OF THREE DIRECT.

This rule teacheth by three numbers given to find a fourth in such proportion to the third, as the second is to the first, for which reason it is called the Rule of Three, from its having three numbers given.

Rule. Set the first term upon B to the second term upon A, and opposite the third term upon B is the fourth upon A; always observing to take the first and third terms on the line B, and the second and fourth upon the line A.

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EXAMPLES.

52. If 6 yards of cloth cost 2s. 6d., what will 72 yards cost?

Ans. 30 shillings.

Set 6 upon B to 2s. 6d., or 2½ upon A, and opposite 72 upon B is 30 shillings upon A, the answer.

53. If 7½ yards of cloth cost 19s., what will 45 yards cost?

Ans. 114 shillings.

Set 7½ upon B to 19 upon A, and opposite 45 upon B is 114 shillings upon A, the answer.

54. If I give £6. 15s. for 4 packs of wool, how many packs can I buy for £81?

Ans. 48 packs.

Set £6 15s. upon B to 4 upon A, and opposite £81 upon B is 48 packs upon A, the answer.

55. If a man can walk 33⅓ miles in 4 hours, in what time will he walk 335 miles?

Ans 40 hours.

Set 33⅓ upon B to 4 upon A, and opposite 335 upon B is 40 hours upon A, the answer.

56. If a man can walk 37½ miles in 5 hours, how long will he be walking 210 miles?

Ans. 28 hours.

Set 37½ upon B to 5 upon A, and opposite 210 upon B, is 28 hours upon A, the answer.

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57. If 4lbs. of candles cost 2s. 6d., what will 72lbs. cost?

Ans. 45 shillings.

Set 4 upon B to 2s. 6d. upon A, and opposite 72 upon B, is 45 shillings upon A, the answer.

58. If 1cwt. of cast iron cost £1. 6s., what will 40 cost?

Ans. £52.

Set 1 upon B to £1. 6s. upon A, and opposite 40 upon B is £52 upon A, the answer.

59. If 24 cost 18s., what will 4 cost?

Ans. 3 shillings.

Set 24 upon B to 18 upon A, and opposite 4 upon B, is 3 shillings upon A, the answer.

60. If 23 cost £1 13s., what will 115 cost?

Ans. £8. 5s.

Set 23 upon B to £1. 13s. upon A, and opposite 115 upon B is £8. 5s. upon A, the answer.

61. If a carding engine throws off 2lbs. of cotton in 22½ minutes, in what time will it throw off 80lbs?

Ans. 900 minutes.

Set 2 upon B to 22½ upon A, and opposite 80 upon A is 900 minutes upon A, the answer.

62. If in a wheel of 12 feet circumference there are 72 teeth, how many teeth are there in a wheel of 16 feet circumference, the pitch being the same?

Ans. 96 teeth.

Set 12 upon B to 72 upon A, and opposite 16 upon B is 96 teeth upon A, the answer.

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63. If a shaft makes 56 revolutions per minute driven by a pulley 42 inches diameter, what is the diameter of another pulley to turn the same shaft 44 revolutions per minute?

Ans. 33 inches diameter.

Set 56 upon B to 42 upon A, and opposite 44 upon B is 33 inches upon A, the answer.

64. If a cistern, containing 240 gallons of water, has a cock which discharges 6 gallons in a minute, and another has a cock which discharges 15 gallons per minute, and both cisterns are emptied in the same same time, how many gallons does this last cistern contain?

Ans. 600 gallons.

Set 6 upon B to 240 upon A, and opposite 15 upon B is 600 gallons upon A, the answer.

65 If 2 men in 3 days earn 15s., how much will 7 men earn in the same time?

Ans. 52s. 6d.

Set 2 upon B to 15 upon A, and opposite 7 upon B is 52s. 6d. upon A, the answer.

66. If 3 bundles of cotton cost 18s., what will 17 bundles cost?

Ans. 102 shillings.

Set 3 upon B to 18 upon A, and opposite 17 upon B is 102 shillings upon A, the answer.

67. If there is 840 yards in one hank, what quantity of hanks will be required to make a warp 1,680 ends broad, and 152 yards long?

Ans. 304 hanks.

Set 840 upon B to 1,680 upon A, and opposite 152 upon B is 304 hanks upon A, the answer.

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68. What will be the weight of 54 yards of cotton delivered from a carding engine at the rate of one hank in the pound?

Ans. 450 grains.

Set 840 upon B to 7,000 upon A, the number of grains in 1lb., and opposite 54 upon B is 450 grains upon A, the answer.

69. If a set of yarn contains 650 hanks, and weighs 6lbs. 8oz., what will be the counts of the yarn?

Ans. 100 hanks.

Set 650 upon B to 6½lbs. upon A, and opposite 1 upon B is 100 hanks upon A, the answer.

70. If a set of yarn is wrapped No. 80's, how many hanks should there be, the set weighing 7lbs. 4oz.

Ans. 580 hanks.

Set 116oz. upon B to 80 upon A, and opposite 840 upon B is 580 hanks upon A, the answer.

71. If a set of yarn is wrapped No. 90's, and contains 360 hanks, required the weight?

Ans. 4lbs.

Set 90 upon B to 360 upon A, and opposite 16oz. upon B is 64oz. upon A; divide by 16, and the weight is 4lbs, the answer.

72. If a column of water 9½ yards deep press with a force equal to 15lbs. on the square inch, what will be the force per square inch if the depth be 45 yards?

Ans. 71lbs.

Set 9½ upon B to 15 upon A, and opposite 45 upon B is 71lbs. upon A, the answer.

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73. If an 8 hank roving produce 105's, what number will a $2\frac{3}{4}$ hank roving produce?

Ans. 36 hanks.

Set 8 upon B to 105 upon A, and opposite $2\frac{3}{4}$ upon B is 36 hanks upon A, the answer.

74. If the diameter of a circle be 7 inches of which the circumference is 22, what is the circumference of another circle whose diameter is 43 inches?

Ans. 135 inches.

Set 7 upon B to 22 upon A, and opposite 43 upon B, is 135 inches upon A, the answer.

75. If a person's salary be £3. 15s. per month, what is that per year? Ans. £45.

Set 1 upon B to £3. 15s. upon A, and opposite 12 months upon B is £45 upon A, the answer.

76. A bar of wood 24 feet long has suspended at each end a weight, the one of 16lbs., the other 4lbs., at what distance from each end must a fulcrum be placed to exactly balance both?

Ans. $19\frac{3}{5}$ long end, $4\frac{1}{5}$ short end.

Add both weights together which will be 20lbs., then set 20 upon B to 24 the length of the lever upon A, and opposite 16 and 4 upon B, is $19\frac{3}{5}$ and $4\frac{1}{5}$ upon A, the answers.

77. A lever is 120 inches long, one end is to make a stroke equal to 10 inches, while the other end passes through a space of 30 inches, what distance from each end must the fulcrum be placed?

Ans. 90 inches long end, 30 inches short end.

Add the two strokes together which will be 40 inches, then set 40 upon B to 120 the length of the lever upon A, and opposite 30 and 10 upon B is 90 and 30 inches upon A, the answers.

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78. If a bar of iron 3 feet long, 3½ inches broad, and ½ inch thick weighs 19lbs., what is the weight of 18 feet?

Ans. 114lbs.

Set 3 upon B to 19 upon A, and opposite 18 upon B is 114lbs. upon A, the answer.

79. The upright shaft in a mill makes 51 revolutions per minute, and the line shaft 30, the wheel on the upright is 15 inches diameter, what is the diameter of the line shaft wheel?

Ans. 25½ inches diameter.

Set 30 upon B to 51 upon A, and opposite 15 upon B is 25½ inches upon A, the answer.

80. If a 6-hank roving produce 150's yarn with a pinion of 24 teeth, what number of hanks will be produced from a 9-hank roving with a 32 change pinion?

Ans. 300 hanks.

This will require two operations. First—Set 6 upon B to 150 upon A, and opposite 9 upon B, is 225's upon A, the numbers a 9-hank roving will produce. Then set 24 upon B to 225 upon A, and opposite 32 upon B, is 300 hanks upon A, the answer.

THE RULE OF THREE INVERSE.

This Rule teacheth by three numbers given to find a fourth that shall have the same proportion to the second, as the first has to the third.

Note. If more requires less, or less requires more, it belongs to this rule, but if more requires more, or less requires less, that question belongs to the Rule of Three Direct.

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Rule. Invert the slide and set the first term upon C to the second term upon A, and opposite the third term upon C is the fourth upon A.

EXAMPLES.

81. Suppose I lend my friend £128 for 8 months, how long ought he to lend me £64 to requite my kindness?

Ans. 16 months.

Invert the slide and set £128 upon C to 8 upon A, and opposite £64 upon C is 16 months upon A, the answer.

82. If 64 men perform a piece of work in 70 days, how many men can perform the same in 40 days?

Ans. 112 men.

Set 64 upon C to 70 upon A, and opposite 40 upon C is 112 men upon A, the answer.

83. If a pasture will feed 32 head of cattle for 6 weeks, how long will it feed 48 head?

Ans. 4 weeks.

Set 32 upon C to 6 upon A, and opposite 48 upon C is 4 weeks upon A, the answer.

84. If when the price of a bushel of wheat is 3s., the penny loaf weighs 18oz., what must the penny loaf weigh when the bushel is worth 4s. 6d.

Ans. 12oz.

Set 3 upon C to 18 upon A, and opposite 4s. 6d. upon C is 12oz. upon A, the answer.

85. If 80lbs. be conveyed 54 miles for £1 9s., how far can I have conveyed 360lbs. for the same money?

Ans. 12 miles.

Set 80 upon C to 54 upon A, and opposite 360lbs. upon C, is 12 miles upon A, the answer.

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86. If 16 pioneers make a trench in 11 days, how many days will 44 men do the same?

Ans. 4 days.

Set 16 upon C to 11 upon A, and opposite 44 upon C is 4 days upon A, the answer.

87. If in 15 years £80 gain £50, in what time will £480 gain the same amount?

Ans. 2½ years.

Set 15 upon C to 80 upon A, and opposite 480 upon C is 2½ years upon A, the answer.

88. If a 15-inch pulley makes 108 revolutions per minute, driving one of 6 inches diameter, required the speed per minute of the latter pulley.

Ans. 270 revolutions.

Set 15 upon C to 108 upon A, and opposite 6 upon C is 270 revolutions upon A, the answer.

89. The line shaft in a mill makes 132 revolutions upon its axis per minute with a pulley 14 inches diameter upon it, driving one of 12 inches diameter placed on the crank of a loom, required the number of picks per minute.

Ans. 154 picks.

Set 14 upon C to 132 upon A, and opposite 12 upon C is 154 picks upon A, the answer.

90 The fly wheel shaft of a steam engine makes 33 revolutions per minute, having a wheel upon it of 104 teeth, required the number of teeth in the driven wheel that the next shaft may make 49 revolutions per minute.

Ans. 70 teeth.

Set 104 upon C to 33 upon A, and opposite 49 upon C is 70 teeth upon A, the answer.

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91. If a 50-inch pulley makes 70 revolutions per minute, driving one of 3½ inches diameter, required the speed of the latter pulley.

Ans. 1000 revolutions.

Set 50 upon C to 70 upon A, and opposite 3½ upon C, is 1000 revolutions upon A, the answer.

92. I am spinning 120's with a pinion of 35 teeth, what pinion will 200's require.

Ans. 21 pinion.

Set 120 upon C to 35 upon A, and opposite 200 upon C is 21 pinion upon A, the answer.

93. If a 15 pinion spin 180's, what counts will a 12's pinion spin?

Ans. 225 hanks.

Set 15 upon C to 180 upon A, and opposite 12 upon C is 225 hanks upon C, the answer.

94. I am weaving a piece of cloth 16 picks to one inch with a pinion of 28 teeth, what pinion must be put on to give 14 picks to the inch?

Ans. 32 pinion.

Set 16 upon C to 28 upon A, and opposite 14 upon C is 32 pinion upon A, the answer.

95. If a 36 pinion gives 93 picks per inch, how many picks will a 22 pinion give?

Ans. 152 picks.

Set 36 upon C to 93 upon A, and opposite 22 upon C is 152 picks upon A, the answer.

96. If a 19 pinion gives 87 picks per inch, what pinion will give 118 picks per inch?

Ans. 14 pinion.

Set 19 upon C to 87 upon A, and opposite 118 upon C is 14 pinion upon A, the answer.

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97. If a set of yarn is wrapped 36's and weighs 3lbs. 9oz. how many hanks should there be?

Ans. 128½ hanks.

Set 36 upon C to 57oz. upon A, and opposite 16oz. upon C is 128½ hanks upon A, the answer.

98. A guide screw has 6 threads in 1 inch, on which is fixed a wheel of 48 teeth, which works in another wheel of 24 teeth, how many threads per inch will be cut upon a plain shaft by these wheels?

Ans. 12 threads.

Set 6 upon C to 48 upon A, and opposite 24 upon C is 12 threads upon A, the answer.

99. If a set of yarn contains 176 hanks, and is wrapped 32's, the weight of the set is required.

Ans. 5lbs. 8oz.

Set 16oz. upon C to 176 upon A, and opposite 32's upon A is 88oz. upon A, equal to 5½lbs., the answer.

100. The change pinion of a silk spinning mill contains 24 teeth, which gives 9 turns to 1 inch, how many turns will an 18 pinion give?

Ans. 12 turns per inch.

Set 24 upon C to 9 upon A, and opposite 18 upon C is 12 turns upon A, the answer.

101. If a pulley 22 inches diameter makes 64 revolutions per minute, driving one of 8 inches diameter, required the speed of the latter pulley.

Ans. 176 revolutions.

Set 22 upon C to 64 upon A, and opposite 8 upon C is 176 revolutions upon A, the answer.

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102. Suppose the fly wheel shaft of a steam engine makes 32 revolutions upon its axis per minute, having a wheel of 116 teeth driving one of 64 teeth staked on the upright; higher up the upright is another wheel of 45 teeth, driving one of 29 teeth; at the other end of the line shaft, is a wheel of 38 teeth driving one of 30 teeth upon a cross shaft; attached to the cross shaft is a pulley of 16½ inches diameter, driving a pulley of 9½ inches diameter;—required the speed of each shaft separately, and the speed of the last pulley per minute.

Answers { Speed of upright 58 revolutions.
„ line shaft 90 „
„ cross shaft 114 „
„ last pulley 198 „

First set 32 upon C to 116 upon A, and opposite 64 upon C is 58 upon A, the speed of the upright.

Then set 45 upon C to 58 upon A, and opposite 29 upon C is 90 upon A, the speed of the line shaft.

Then set 38 upon C to 90 upon A, and opposite 30 upon C is 114 upon A, the speed of the cross shaft.

Then set 16½ upon C to 114 upon A, and opposite 9½ upon C is 198 upon A, the speed of the last pulley.

To this rule belongs those questions applicable to the lever,* of which there are three kinds or varieties, depending upon the position and the application of a certain fixed point called the fulcrum, on which the lever is supposed to move freely. Those portions of the lever situated on each side of the fulcrum are called the arms of the lever.

A lever of the first kind is shown upon the opposite page in Fig. 1, in which the fulcrum F is situated between the moving power P and the resistance W.

Fig. II. is a lever of the second kind, in which the mover P and the resistance W act on the same side of

* See Tomlinson's Rudimentary Mechanics, page 32.

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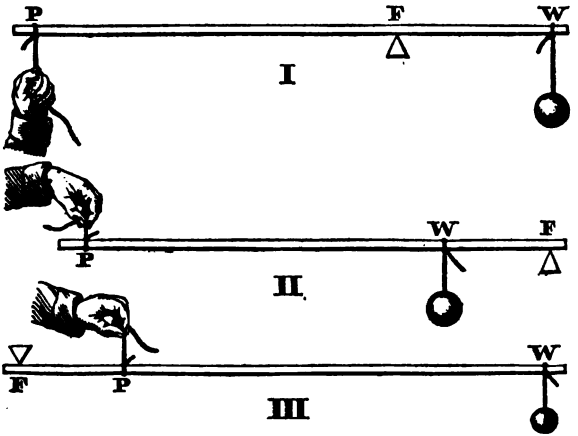
the fulcrum, the load moved being between the fulcrum and the mover.

Fig. III. is a lever of the third kind; the mover P and the load W also act on the same side of the fulcrum, but the mover P is between the fulcrum F and the load W.



THE FIRST KIND.

103. The short arm of a lever is 2 inches long, at the end is a weight of 670lbs., the long arm is 33½ inches; what weight must be applied at the extreme end in order to raise the weight?

Ans. 40lbs.

Set 2 upon C to 670 upon A, and opposite 33½ upon C is 40lbs. upon A, the answer.

104. If 40lbs. be suspended on the end of a lever 56 inches from the fulcrum, what weight may be balanced 3½ inches on the other side of the fulcrum?

Ans. 640lbs.

Set 40 upon C to 56 upon A, and opposite 3½ upon C is 640lbs. upon A, the answer.

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105. If 360lbs. be suspended 3¾ inches from the fulcrum, at what distance must 18lbs. be applied on the other side of the fulcrum to produce an equilibrium.

Ans. 75 inches.

Set 360 upon C to 3¾ upon A, and opposite 18 upon C is 75 inches upon A, the answer.

THE SECOND KIND.

106. If a lever, having the fulcrum at one end, and 2½ inches from the fulcrum be suspended 78lbs., at what distance must 5lbs. be applied in order to raise the weight?

Ans. 39 inches.

Set 2½ upon C to 78 upon A, and opposite 5 upon C is 39 inches upon C, the answer.

107. If a lever, 25 inches long, having a fulcrum at one end, and 5 inches from the fulcrum is suspended 112lbs., how far from the fulcrum must 28lbs. be applied in order to raise the weight?

Ans. 20 inches.

Set 5 upon C to 112 upon A, and opposite 28 upon C is 20 inches upon A, the answer.

108. If a lever, 48 inches long, having a fulcrum at one end, and 4 inches from the fulcrum be suspended 55lbs., what force must be applied at the end of the lever in order to raise the weight?

Ans. 5lbs.

Set 4 upon C to 55 upon A, and opposite 44 inches, the length of the lever upon C, is 5lbs. upon A, the answer.

THE THIRD KIND.

109. Suppose the lever of a safety valve to be 60 inches long, having a fulcrum at one end, the spindle of the valve is 4 inches from the fulcrum, and at the other end

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is a weight of 20lbs., at what pressure will the steam escape, supposing the area of the valve to be one square inch?

Ans. 75lbs. pressure.

Set 20 upon C to 56 upon A, the length of the longest arm, and opposite 15* upon C is 75lbs. pressure upon A, the answer.

110. Suppose the lever of a safety valve to be 48in. long, the fulcrum at one end, and 22½lbs. suspended at the other end; 6 inches from the fulcrum is the spindle of the valve, and its area equal to 12 square inches;—at what pressure will the steam escape?

Ans. 15lbs. pressure.

Set 48 upon C to 22½ upon A, and opposite 6 upon C is 180lbs. upon A, the pressure upon the valve; divide 180 by 12, and it quotes 15lbs. pressure, the answer.

VULGAR AND DECIMAL FRACTIONS.

A fraction is one or more parts of a thing, and supposes the unit divided into a number of parts. It is expressed by two numbers, one above the other, with a line between them, as $\frac{3}{8}$, $\frac{7}{8}$, $\frac{1}{4}$. The upper number is called the numerator, and shows how many of these parts the fraction contains, as $\frac{1}{8}$ is equal to one-eighth part, $\frac{3}{7}$ is equal to three-seventh parts, &c. The lower number is called the denominator, and shows the number of parts into which the unit is divided.

To reduce a vulgar fraction to its decimal expression.

Rule. Set the denominator upon B to the numerator upon A, and opposite 100 upon B is the decimal required upon A.

* See Fig. III. In this lever W P is 15 times greater than F P.

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EXAMPLES.

111. Reduce $\frac{3}{4}$ to its decimal expression.

Ans. ·75.

Set 4 upon B to 3 upon A, and opposite 100 upon B is 75 upon A, the answer.

112. Reduce $\frac{5}{8}$ to its decimal expression.

Ans. ·625.

Set 8 upon B to 5 upon A, and opposite 100 upon B is ·625 upon A, the answer.

113. Reduce $\frac{3}{8}$ to its decimal expression.

Ans. ·375.

Set 8 upon B to 3 upon A, and opposite 100 upon B is ·375 upon A, the answer.

114. Reduce $\frac{1}{8}$ to its equivalent decimal expression.

Ans. ·125

Set 8 upon B to 1 upon A, and opposite 100 upon B is ·125 upon A, the answer.

115. Reduce $\frac{1}{4}$ to its decimal expression.

Ans. ·25.

Set 4 upon B to 1 upon A, and opposite 100 upon B is ·25 upon A, the answer.

116. Reduce $\frac{4}{7}$ to a decimal. Ans. ·571

Set 7 upon B to 4 upon A, and opposite 100 upon B is ·571 upon A, the answer.

117. Reduce $\frac{7}{16}$ to a decimal. Ans. ·4375.

Set 16 upon B to 7 upon A, and opposite 100 upon B is ·4375 upon A, the answer.

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118. Reduce $\frac{4}{7}$ to a decimal. Ans. ·133.

Set 15 upon B to 2 upon A, and opposite 100 upon B is ·133 upon A, the answer.

119. Reduce $\frac{7}{36}$ to a decimal. Ans. ·194.

Set 36 upon B to 7 upon A, and opposite 100 upon B is ·194 upon A, the answer.

120. Reduce $\frac{18}{56}$ to a decimal. Ans. ·321

Set 56 upon B to 18 upon A, and opposite 100 upon B is ·321 upon A, the answer.

121. Reduce $\frac{7}{8}$ to a decimal. Ans. ·875.

Set 8 upon B to 7 upon A, and opposite 100 upon B is ·875 upon A, the answer.

122. Reduce $\frac{9}{12}$ to a decimal. Ans. ·75.

Set 12 upon B to 9 upon A, and opposite 100 upon B is ·75 upon A, the answer.

EXTRACTION OF THE SQUARE ROOT.

Extraction of the square root is to find out such a number as, being multiplied into itself, the product will be equal to the given number.

Rule. Set the slide even at both ends, then the line C is a table of squares and the line D is a table of roots. For opposite any number upon C is its square root upon D, as in the following table :—

Squares upon C...	1	4	9	16	25	36	49	64	81	100
Roots upon D.....	1	2	3	4	5	6	7	8	9	10

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EXAMPLES.

123. Extract the square root of 225. Ans. 15.

Set the slide even at both ends, as before directed, and opposite 225 upon C is 15 upon D, the answer.

124. Extract the root of 841. Ans. 29.

Opposite 841 upon C is 29 upon D, the answer.

125. Extract the square root of 625. Ans. 25.

Opposite 625 upon C is 25 upon D, the answer.

126. If the top of a castle from the ground be 45 yards. and surrounded with a river 60 yards broad, what length must the ladder be to reach from the outside of the river to the top of the castle?

Ans. 75 yards.

Opposite 45 upon D is 2025 upon C, the square of the perpendicular, and opposite 60 upon D is 3600 upon C, the square of the base, add the two squares together, and the sum is 5625; find 5625 upon C, and opposite is 75 yards, the answer.

CASE 2.

To find a mean proportional between two numbers.

Rule. Set one of the numbers upon C to the same number upon D, and opposite the other number upon C is the mean proportional sought upon D.

EXAMPLES.

127. What is the mean proportional between 16 and 36?

Ans. 24.

Set 16 upon C to 16 upon D, and opposite 36 upon C is 24 upon D, the answer.

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128. What is the mean proportional between 16 and 64? Ans. 32.

Set the slide as before, and opposite 64 upon C is 32 upon D, the mean proportional sought.

129. If a shaft, making 16 revolutions per minute, give motion to a third shaft, making 121 revolutions per minute, required the revolutions of the intermediate shaft.

Ans. 44 revolutions.

Set 16 upon C to 16 upon D, and opposite 121 upon C is 44 upon D, the answer.

130. If of three shafts the first makes 18 revolutions and the third 32 revolutions in the same time, how many revolutions should the second shaft make?

Ans. 24 revolutions.

Set 18 upon C to 18 upon D, and opposite 32 upon C is 24 upon D, the answer.

131. What is the mean square between $3\frac{1}{2}$ broad and $\frac{3}{8}$ thick? Ans. 4·50.

Set ·625 upon C to ·625 upon D, and opposite $3\frac{1}{2}$ upon C is 4·50 upon D, the answer.

132. The breadth of a bar of iron is $2\frac{3}{4}$in. and $\frac{3}{8}$in. thick, what is the mean square?

Ans. 3·21.

Set ·375 upon C to ·375 upon D, and opposite $2\frac{3}{4}$ upon C is 3·21 upon D, the mean square.

133. To find a mean square between the breadth and depth of a cistern, whose breadth is 36in. and depth 24in.

Ans. 29·39.

Set 36 upon C to 36 upon D, and opposite 24 upon C is 29·39 upon D, the mean square.

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134. What is the mean proportional between 9 and 4?
Ans. 6.

Set 9 upon C to 9 upon D, and opposite 4 upon C is 6 upon D, the answer.

CUBE ROOT.

To extract the cube root is, to find out a number which being multiplied into itself, and then again into itself, the product is equal to the given number.

Rule. Invert the slide, and set the given number upon B to 1 or 10 upon D, and the root will be found where equal value coincide on the two lines B and D.

EXAMPLES.

135. Extract the cube root of 216.
Ans. 6.

Invert the slide, and set 216 upon B to 10 upon D, and opposite 6 upon B is 6 upon D, the root of 216.

136. Extract the cube root of 343.
Ans. 7.

Set 343 upon B to 10 upon D, and opposite 7 upon B is 7 upon D, the cube root of 343.

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Case 2.

To cube a given number by one operation.

Rule. Set the given number upon C to 1 or 10 upon D, and opposite the same number upon D is the cube number upon C.

EXAMPLES.

137. What is the cube of 9.

Ans. 729.

Set 9 upon C to 10 upon D, and opposite 9 upon D is 729 upon C, the answer.

138. What is the cube of 8.

Ans. 512.

Set 8 upon C to 10 upon D, and opposite 8 upon D is 512 upon C, the answer.

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SUPERFICIAL MENSURATION.

THE area of any plane figure is its superficial content, or the measurement of its surface without any regard to thickness.

CASE 1.

Given the length in feet and breadth in inches to find the content.

Rule. Set the breadth upon B to 12 upon A, and opposite the length upon A is the content upon B.

EXAMPLES.

139. What is the superficial content of a board 18 feet long and 11 inches broad?

Ans. 16½ square feet.

Set 11 upon B to 12 upon A, and opposite 18 upon A is 16½ square feet upon B, the answer.

140. What is the content of a board 17 inches broad and 30 feet long?

Ans. 42½ square feet.

Set 17 upon B to 12 upon A, and opposite 30 upon A is 42½ square feet upon B, the answer.

141. Required the content of a board 5 inches wide and 18 feet long.

Ans. 7½ square feet.

Set 5 upon B to 12 upon A, and opposite 18 upon A is 7½ feet upon B, the answer.

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142. What is the content of a board 60 feet long and 11 inches wide?

Ans. 55 feet.

Set 11 upon B to 12 upon A, and opposite 60 upon A is 55 feet upon A, the answer.

143. What is the content of a board 26 feet 8 inches long and 9 inches broad?

Ans. 20 feet.

Set 9 upon B to 12 upon A, and opposite 26 feet 8 inches upon A is 20 feet upon B, the answer.

144. A door is 6 feet 9 inches long and 36 inches wide; required the content.

Ans. 20¼ feet.

Set 36 upon B to 12 upon A, and opposite 6 feet 9 inches upon A is 20¼ feet upon B, the answer.

145. The bottom of a cistern is 5 feet long and 54 inches wide; required the content.

Ans. 22½ feet.

Set 54 upon B to 12 upon A, and opposite 5 upon A is 22½ feet upon B, the answer.

Case 2.

Given the length and breadth in inches to find the content.

Rule. Set the breadth upon B to 144 upon A, and opposite the length upon A is the content upon B.

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EXAMPLES.

146. A pane of glass is 27 inches long by 24 inches wide; required the content.

Ans. $4\frac{1}{2}$ feet.

Set 24 upon B to 144 upon A, and opposite 27 upon A is $4\frac{1}{2}$ feet upon B, the answer.

147. What is the content of a pane of glass 32 inches long by 18 inches wide?

Ans. 4 feet.

Set 18 upon B to 144 upon A, and opposite 32 upon A is 4 feet upon B, the answer.

148. What is the content of a board $7\frac{1}{2}$ inches wide and 40 inches long.

Ans. $2\frac{1}{2}$ feet.

Set $7\frac{1}{2}$ upon B to 144 upon A, and opposite 40 upon A is $2\frac{1}{2}$ feet upon B, the answer.

149. What is the content of a shutter 60 inches long by 54 inches wide?

Ans. $22\frac{1}{2}$ feet.

Set 54 upon B to 144 upon A, and opposite 60 upon A is $22\frac{1}{2}$ feet upon B, the answer.

CASE 3.

Given the length and breadth in feet to find the content in square yards.

Rule. Set the breadth upon B to 9 upon A, and opposite the length upon A is the content in square yards upon B.

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EXAMPLES.

150. A partition measures 45 feet long and 36 feet wide; how many square yards does it contain?

Ans. 180 square yards.

Set 36 upon B to 9 upon A, and opposite 45 upon A is 180 square yards upon B, the answer.

151. A ceiling measures 15 feet wide by 38 feet long; required the content in square yards.

Ans. 63 yards 3 feet.

Set 15 upon B to 9 upon A, and opposite 38 upon A is $63\frac{1}{3}$ yards upon B, the answer.

CASE 4.

Given the length and breadth, in chains, to find the content in acres.

Rule. Set the length upon B to 1 or 10 upon A, and opposite the breadth upon A is the content in acres and parts upon B.

EXAMPLE.

152. How many acres are contained in a plot of land 17 chains 50 links long by 4 chains broad?

Ans. 7 acres.

Set $17\frac{1}{2}$ upon B to 10 upon A, and opposite 4 upon A is 7 acres upon B, the answer.

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Case 5.

Given the length and breadth, in perches, to find the content in acres.

Rule. Set the length upon B to 160 upon A, and opposite the breadth upon A is the content upon B in acres.

EXAMPLE.

153. What is the content of a field whose length is 72 perches, and its breadth 40 perches?

Ans. 18 acres.

Set 72 upon B to 160 upon A, and opposite 40 upon A is 18 acres upon B, the answer.

Case 6.

Given the length and breadth, in yards, to find the content in acres.

Rule. Set the length upon B to 4840 upon A, and opposite the breadth upon A is the content upon B in acres.

EXAMPLE.

154. What is the content of a piece of land 220 yards long by 66 yards wide?

Ans. 3 acres.

Set 220 upon B to 4840 upon A, and opposite 66 upon A is 3 acres upon B, the answer.

Case 7.

To find the area of a regular polygon.

Rule. Set the tabular number upon C to 1 or 10 upon D, and opposite the length of one of the sides upon D is the area upon C.

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No. of Sides.	Names.	Tabular Numbers.
3	Trigon	·433
4	Tetrigon	1·000
5	Pentagon	1·720
6	Hexagon	2·598
7	Heptagon	3·634
8	Octagon	4·828
9	Nonagon	6·182
10	Decagon	7·694
11	Undecagon	9·366
12	Duodecagon	11·196

EXAMPLES.

155. Required the area of a trigon, or triangle, whose side is 18 feet.

Ans. 140 feet.

Set ·433 upon C to 10 upon D, and opposite 18 upon D is 140 feet, the area upon C.

156. Required the area of a pentagon whose side is 9 inches.

Ans. 139 inches.

Set 1·72 upon C to 10 upon D, and opposite 9 upon D is 139 inches upon C, the area.

157. Required the area of an hexagon whose side is 5 feet.

Ans. 64¾ feet.

Set 2·598 upon C to 10 upon D, and opposite 5 upon D is 64¾ feet upon C, the area.

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158. Required the area of an heptagon whose side is 17 feet.

Ans. 1050 feet.

Set 3·634 upon C to 10 upon D, and opposite 17 upon D is 1050 feet upon C, the area.

159. Required the area of an octagon whose side is 15 inches.

Ans. 1086 inches.

Set 4·828 upon C to 10 upon D, and opposite 15 upon D is 1086 inches upon C, the area.

160. Required the area of a nonagon whose side is 8 feet.

Ans. 55½ feet.

Set 6 182 upon C to 10 upon D, and opposite 13 upon D is 55½ feet upon C, the area,

161. Required the area of a decagon whose side is 13 inches.

Ans. 1300 inches.

Set 7·694 upon C to 10 upon D, and opposite 13 upon D is 1300 inches upon C, the area.

162. Required the area of an undecagon, whose side is 7 inches.

Ans. 458 inches.

Set 2·366 upon C to 10 upon D, and opposite 7 upon D is 458 inches upon C, the area.

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163. Required the area of a duodecagon, each side being 5 feet.

Ans. 280 feet.

Set 11·196 upon C to 10 upon D, and opposite 5 upon D is 280 feet upon C, the area required.

Case 8.

Given the diameter of a circle to find the circumference: or the circumference to find the diameter.

Rule 1. Set 7 upon B to 22 upon A and opposite any diameter upon B is the circumference upon A, or *vice versa*.

Rule 2. Set 1 upon B to 3·1416 upon A, and opposite any diameter upon B is the circumference upon A, or *vice versa*.

EXAMPLES.

164. If the diameter of a cylinder be 16 inches, what will be the circumference.

Ans. 50¼ inches.

Set 7 upon B to 22 upon A, and opposite 16 upon B is 50¼ inches upon A, the answer.

165. What is the circumference of a cylinder 21 inches in diameter.

Ans. 65¾ inches.

Set 7 upon B to 22 upon A, and opposite 21 upon B is 65¾ inches upon A, the answer.

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166. If the diameter of a doffing cylinder be 11 inches, what is the circumference.

Ans. 34½ inches.

Set 7 upon B to 22 upon A, and opposite 11 upon B is 34½ inches upon A, the answer.

167. The diameter of a carding engine is 51¼ inches, how many cards 4 inches broad will cover the same.

Ans. 40¼.

Set 1 upon B to 3·1416 upon A, and opposite 51¼ upon B is 161 upon A the circumference, which number divide by 4 and the quotient is 40¼ cards, the answer.

168. A drawing frame roller is 1½ inches in diameter, required the circumference.

Ans. 4·7 inches.

Set 1 upon B to 3·1416 upon A, and opposite 1½ upon B is 4·7 inches upon A, the circumference.

169. The circumference of a wheel is 245 inches, required the diameter.

Ans. 78 inches.

Set 7 upon B to 22 upon A, and opposite 245 upon A, is 78 inches upon B, the diameter.

170. The circumference of a cylinder is 78½ inches; what is the diameter?

Ans. 25 inches.

Set 1 upon B to 3·1416 upon A, and opposite 78½ upon A is 25 inches upon B, the diameter.

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171. What is the diameter of a wheel whose circumference is 260¾ inches.

Ans. 83 inches.

Set 1 upon B to 3·1416 upon A, and opposite 260¾ upon A is 83 inches upon B, the answer.

Case 9.

Given the diameter to find the area of a circle, or the area to find the diameter.

Rule. Set ·7854 upon C to 1 upon 10 upon D, and opposite any diameter upon D is the area upon C, or *vice versa*.

EXAMPLES.

172. Required the area of a steam-engine piston whose diameter is 35 inches.

Ans. 962·1 inches.

Set ·7854 upon C to 10 upon D, and opposite 35 upon D is 962·1 inches upon C, the area required.

173. The diameter of a safety-valve is 4¼ inches; required the area.

Ans. 14·18 inches.

Set ·7854 upon C to 10 upon D, and opposite 4¼ upon D is 14·18 upon C, the area.

174. The area of a piston is 572½ inches; required the diameter.

Ans. 27 inches.

Set ·7854 upon C to 10 upon D, and opposite 572½ upon C is 27 inches upon D, the answer.

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175. The area of a circle is 615¾ inches; what is the diameter?

Ans. 28 inches.

Set ·7854 upon C to 10 upon D, and opposite 615¾ upon C is 28 inches upon D, the answer.

Case 10.

Given the circumference to find the area, or the area given to find the circumference.

Rule. Set ·795 upon C to 10 upon D, and opposite any circumference upon D is the area upon C; or opposite the area upon C is the circumference upon D.

EXAMPLES.

176. The circumference of a cylinder is 60 inches; required the area.

Ans. 286½ inches.

Set ·795 upon C to 10 upon D, and opposite 60 upon D is 286½ inches upon C, the answer.

177. The area of a piston contains 420 inches; what is the circumference?

Ans. 72·6 inches.

Set ·795 upon C to 10 upon D, and opposite 420 upon C is 72·6 upon D, the circumference.

Case 11.

To find the side of a square inscribed in a circle.

Rule. Set ·707 upon B to 1 or 10 upon A, and opposite any diameter upon A is the side of its inscribed square.

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EXAMPLES.

178. What is the greatest side of a square inscribed in a circle whose diameter is 8½ inches?

Ans. 6 inches.

Set ·707 upon B to 1 upon A, and opposite 8½ upon A is 6 inches upon B, the answer.

179. If the diameter of a circle be 29 inches, what will be the side of an inscribed square?

Ans. 20½ inches.

Set ·707 upon B to 10 upon A, and opposite 29 upon A is 20½ inches upon B, the answer.

Case 12.

To find the side of an equilateral triangle inscribed in a circle.

Rule. Set ·115 upon B to 1 or 10 upon A, and opposite any diameter of a circle upon B is the length of one of its sides upon A.

EXAMPLES.

180. What is the side of a triangle inscribed in a circle whose diameter is 15 inches?

Ans. 13 inches.

Set ·115 upon B to 1 upon A, and opposite 15 upon B is 13 inches upon A, the answer.

181. If the diameter of a circle be 12 inches, what will be the side of an inscribed triangle?

Ans. 10·4 inches.

Set ·115 upon B to 1 upon A. and opposite 12 upon B is 10·4 inches upon A, the answer.

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Case 13.

Given the diameter to find the side of a square equal in area.

Rule. Set ·886 upon B to 1 or 10 upon A, and opposite any diameter of a circle upon A is the side of a square equal in area upon B.

EXAMPLE.

182. If the diameter of a circle be 26 inches, what is the side of a square equal in area?

Ans. 23 inches.

Set ·886 upon B to 10 upon A, and opposite 26 upon A is 23 inches upon B, the answer.

MENSURATION OF SOLIDS.

Solid bodies are such as consist of length, breadth, and thickness, as stones, globes, timber, etc. etc.

To ascertain the capacity, content, solidity, or weight of any solid body, the divisors or gauge points marked upon the bottom leg of the rule are always to be made use of, and must now be explained.

The first, second, and third tables are marked Square—Cylinder—Globe. The fourth table is a series of divisors, or gauge points, of polygons from 5 to 12 sides, as given in case 7 of superficial mensuration.

The fifth table is marked G.P.S. of a circle, which denotes the gauge points of a circle.

The sixth table is marked Pumping Engines, for finding the diameters of steam-engine cylinders that will work pumps from 3 to 30 inches diameter, at a given number of yards in depth.

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There are three gauge points under square marked F.F.F., F.I.I., I.I.I. Those figures under F.F.F. are to be used only when the dimensions are all in feet: as 9 feet long, 6 feet broad, and 5 feet deep.

Those figures under F.I.I. are to be used when the dimensions are given in feet and inches; as 18 feet long, 13 inches broad, and 9 inches deep.

Those figures under I I.I. are to be used when the dimensions are given in inches; as 60 inches long, 27 inches broad, and 19 inches deep.

There are two gauge points for all things having a cylindrical form, marked F.I. and I.I. Those figures under F.I. are to be used when the length is given in feet and the diameter in inches; as 12 feet long and 88 inches diameter. Those figures under I.I. are to be made use of when the length and diameter is given in inches; as 27 inches long and 13 inches diameter.

There are also two gauge points for globular forms, marked F. and I. Those figures under F. are to be made use of when the diameter is given in feet. Those figures under I. are to be used when the diameter is given in inches.

In measuring or weighing solid bodies having unequal sides a mean proportion must be found to arrive at the true square.—*See case 2nd in Square Root.*

Note.—Firstly. That all the gauge points are to be found upon the line A.

Secondly. That all the lengths are to be found upon the line B.

Thirdly. That all the contents are to be found upon the line C.

Fourthly. That all the squares and diameters are to be found upon the line D.

Rule. Set the length upon B to the gauge point upon A, and opposite the square or diameter upon D is the content or weight upon the line C.

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EXAMPLES.

183. A log of timber is 18 feet long, 3 feet broad, and 2 feet deep; required the content.

Ans. 108 cubic feet.

Find a mean square between the breadth and depth by setting 3 upon C to C upon D, and opposite 2 upon C is 2·45 upon D, the mean square. Then set 18 upon B to 1 upon A, the gauge point, and opposite 2·45 upon D is 108 feet upon C, the content required.

184. Required the solidity of a piece of timber 16 feet long, 9 inches broad, and 4 inches deep.

Ans. 4 cubic feet.

Find a mean square. Set 9 upon C to 9 upon D, and opposite 4 upon C is 6 upon D, the mean square. The gauge point under F.I.I. for cubic feet is 144. Set 16 upon B to 144 upon A, and opposite 6 upon D is 4 cubic feet upon C, the answer.

185. What is the solidity of a block of stone 60 inches long, 36 inches broad, and 4 inches thick?

Ans. 5 cubic feet.

Find a mean square. Set 36 upon C to 36 upon D, and opposite 4 upon C is 12 upon D, the mean square. Set 60 upon B to 1728 upon A, the gauge point, and opposite 12 upon D is 5 feet upon C, the answer.

186. Required the cubical contents of a steam-engine cylinder, the length 4 feet, and diameter 24 inches.

Ans. 12¼ cubic feet.

The gauge point under F.I. for cylinder is 1833. Set 4 upon B to 1833 upon A, and opposite 24 upon D is 12¼ feet upon C, the answer.

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187. How many cubical inches are there in a cylinder 7 inches long and 9 inches in diameter?

Ans. 445.

The guage point under I.I. for cylinder is 1273. Set 7 upon B to 1273 upon A, and opposite 9 upon D is 445 cubic inches upon C, the answer.

188. Suppose the ball on the top of St. Paul's Cathedral to be 6 feet diameter, how many cubical feet does it contain?

Ans. 113 cubic feet.

The globular guage point under F. is 191. Set 6 upon B to 191 upon A, and opposite 6 upon D is 113 feet upon C, the answer.

189. What is the solidity of a globe whose diameter is 9 inches? Ans. 381 solid inches.

The guage point is 191. Set 9 upon B to 191 upon A, and opposite 9 upon D is 381 inches upon C, the answer.

190. What is the solidity of a cone 12 inches long and 12 inches diameter at the base?

Ans. 452 inches.

For the contents of a cone take one-third of the slant height, equal to 4 inches. Set 4 upon B to 1273, the cylindrical guage point upon A, and opposite 12 upon D is 452 inches upon C, the answer.

THE WEIGHING OF METALS.

This rule is of great use to Engineers, Boiler Makers, Blacksmiths, Mechanics, Moulders, Millwrights, &c., in preparing estimates for shafting, piping, palisades, &c.

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It is performed in the same manner as the preceding examples, all the answers being avoirdupois weight.

Rule. For square and round metals. Set the length upon B to the guage point upon A, and opposite the square, or diameter, upon the line D is the weight in pounds and parts upon C.

EXAMPLES.

191. What is the weight of a wrought-iron shaft 8 feet long and 2 inches diameter?

Ans. 84¾ lbs.

The guage point under F.I. for cylinders, in a line with wrought-iron, is 378. Set 8 upon B to 378 upon A, and opposite 2 upon D is 84¾ lbs. upon C, the answer.

192. Required the weight of a wrought-iron shaft 16 feet long and 1¾ inches diameter.

Ans. 130 lbs.

Set 16 upon B to 378 upon A, and opposite 1¾ upon D is 130 lbs. upon C, the answer.

193. What is the weight of a wrought-iron shaft 18 feet long and 2⅞ inches diameter?

Ans. 395 lbs.

Set 18 upon B to 378 upon A, and opposite 2⅞ upon D is 395 lbs. upon C, the answer.

194. If the fly wheel shaft of a steam engine is 10 feet long and 6 inches diameter, what will be its weight in wrought-iron?

Ans. 955 lbs.

Set 10 upon B to 378 upon A, and opposite 6 upon D is 955 lbs. upon C, the answer.

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195. Required the weight of a bar of copper 12 feet long and $1\frac{1}{2}$ inches square.

Ans. 104 lbs.

Set 12 upon B to 26 upon A, the copper gauge point, and opposite $1\frac{1}{2}$ upon D is 104 lbs. upon C, the answer.

196. A block of cast-lead is 4 feet long and 6 inches square; required its weight.

Ans. 710 lbs.

Set 4 upon B to 203 upon A, the lead gauge point, and opposite 6 upon D is 710lbs. upon C, the answer.

197. What is the weight of a column of mercury 59 inches long and 1 inch square?

Ans. 29 lbs.

Set 59 upon B to 203 upon A, the gauge point, and opposite 1 upon D is 29 lbs. upon C, the answer.

198. What is the weight of a rod of gold 36 inches long and 1 inch square?

Ans. 2·56 lbs.

Set 36 upon B to 141 upon A, the gauge point, and opposite 1 upon D is 2·56 lbs. upon C, the answer.

199. Required the weight of a wrought-iron shaft 5 feet long and $6\frac{3}{4}$ inches square.

Ans. 770 lbs.

Set 5 upon B to 297 upon A, and opposite $6\frac{3}{4}$ upon D is 770 lbs. upon C, the answer.

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200. What is the weight of a brass rod 6 feet long and $\frac{3}{4}$ inch diameter? Ans. $9\frac{1}{2}$ lbs.

Set 6 upon B to 354 upon A, the gauge point, and opposite 75 upon D is $9\frac{1}{2}$ lbs. upon C, the answer.

201. What is the weight of a cast-iron shaft 18 feet long and $3\frac{1}{2}$ inches diameter?

Ans. 542 lbs.

Set 18 upon B to 407, the cast-iron gauge point, upon A, and opposite $3\frac{1}{2}$ upon D is 542 lbs. upon C, the answer.

202. Required the weight of a brass roller 40 inches long and 3 inches diameter.

Ans. 85 lbs.

Set 40 upon B to 424 upon A, the gauge point, and opposite 3 upon D is 85 lbs. upon C, the answer.

203. What is the weight of a copper rod 6 feet long and $\frac{5}{8}$ inch diameter? Ans. 7 lbs.

Set 6 upon B to 331 upon A, the gauge point, and opposite ·625 upon D is 7 lbs. upon C, the answer.

204. What is the weight of a silver rod 36 inches long and $\frac{3}{4}$ inch diameter? Ans. 6lbs.

Set 36 upon B to 334 upon A, the gauge point, and opposite ·75 upon D is 6 lbs. upon C, the answer.

205. What is the weight of a bar of steel 10 feet long and $1\frac{1}{2}$ inches diameter?

Ans. 61 lbs.

Set 10 upon B to 372 upon A, the gauge point, and opposite $1\frac{1}{2}$ upon D is 61 lbs. upon C, the answer.

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206. Required the weight of a cast-iron shaft, 9 feet long and 12 inches diameter.

Ans. 3200 lbs.

Set 9 upon B to 407 upon A, the gauge point, and opposite 12 upon D is 3200 lbs. upon C, the answer.

207. What is the weight of a brass roller 8 feet long and 3 inches diameter, having 6 necks upon it, each 4 inches long and 2 inches diameter?

Ans. 174½ lbs.

First weigh 6 feet of 3 inches round, then weigh 2 feet 2 inches diameter; add both the weights together for the answer. Set 6 upon B to 354 upon A, the gauge point, and opposite 3 upon D are 152 lbs. upon C. Then set 2 upon B to 354 upon A, and opposite 2 upon D is 22½ upon C. Add 152 and 22½; the sum is 174½ lbs., the answer.

208. What is the weight of a wrought-iron shaft 14 feet long and 2¾ inches diameter, having 4 bosses upon it, each boss 6 inches long and 4 inches diameter?

Ans. 325 lbs.

Set 12 upon B to 378 upon A, and opposite 2¾ upon D are 240 lbs. upon C. Then set 2 upon B to 378 upon A, and opposite 4 upon D are 85 lbs. upon C; add 240 and 85—the sum is 325 lbs. the ans.

209. A cast-iron shaft is 5 feet long and 5¼ inches diameter, having 2 bosses upon it 9 inches long and 6½ inches diameter; required the weight of the shaft.

Ans. 393 lbs.

Set 3½ feet upon B to 407 upon A the gauge point, and opposite 5¼ upon D are 237 lbs. upon C.

Then set 1½ feet upon B to 407 upon A, and opposite 6½ upon D are 156 lbs. upon C; add 237 lbs. to 156, and the sum are 393 lbs, the answer.

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210. What is the weight of a piece of wrought-iron 12 inches long and $2\frac{1}{2}$ inches diameter?

Ans. $16\frac{1}{2}$ lbs.

Set 12 upon B to 453 upon A the gauge point, and opposite $2\frac{1}{2}$ upon D are $16\frac{1}{2}$ lbs. upon C the ans.

EXAMPLES IN FLAT METALS.

In weighing flat metals a mean proportion must be found between the breadth and thickness to arrive at the true square, then proceed by the last rule.

211. What is the weight of a bar of wrought-iron 15 feet long, $3\frac{1}{4}$ inches broad, and $\frac{5}{8}$ of an inch thick?

Ans. 103 lbs.

Set ·625 upon C to ·625 upon A, and opposite $3\frac{1}{4}$ upon C is 4·50 upon D, the mean square. Set 15 feet upon B to 297 upon A, the gauge point, and opposite 4·50 upon D are 103 lbs. upon C, the answer.

212. What is the weight of a bar of iron 12 feet long, $4\frac{1}{4}$ inches broad, and $\frac{5}{8}$ of an inch thick?

Ans. 120 lbs.

Set ·625 upon B to ·625 upon A, and opposite $4\frac{1}{4}$ upon C is 5·45 upon D, the mean square. Set 12 upon B to 297 upon A, and opposite 5·45 upon D are 120 lbs. upon C. the answer.

213. What is the weight of a wrought-iron bar $2\frac{3}{4}$ inches broad, $\frac{3}{8}$ of an inch thick, and 18 feet long?

Ans. $62\frac{3}{4}$ lbs.

Set ·375 upon C to ·375 upon D, and opposite $2\frac{3}{4}$ upon C is 3·21 upon D, the mean square. Set 18 upon B to 297 upon A, and opposite 3·21 upon D are $62\frac{3}{4}$ lbs. upon C, the answer.

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214. What is the weight of a bar of wrought-iron 6 inches broad, $\frac{3}{4}$ inch thick, and 5 feet long?

Ans. 76 lbs.

Set ·75 upon C to ·75 upon D, and opposite 6 upon C is 6·70 upon D the mean square. Set 5 upon B to 297 upon A, and opposite 6·70 upon D are 76 lbs. upon C, the answer.

215. How many pounds will a bar of brass weigh, 5 inches broad, $\frac{5}{8}$ of an inch thick, and 6 feet long?

Ans. 86 lbs.

Set ·625 upon C to ·625 upon D, and opposite 5 upon C is 5·60 upon D, the mean square. Set 6 upon B to 218 upon A, and opposite 5·60 upon D are 86 lbs. upon C, the answer.

216. What is the weight of a piece of copper $2\frac{3}{4}$ inches broad, $\frac{3}{4}$ of an inch thick, and 28 inches long?

Ans. $18\frac{1}{2}$ lbs.

Set ·75 upon C to ·75 upon D, and opposite $2\frac{3}{4}$ upon C is 4 54 upon D, the mean square. Set 28 upon B to 312 upon A, and opposite 4·54 upon D are $18\frac{1}{2}$ lbs. upon C, the answer.

217. What is the weight of a bar of steel $5\frac{1}{4}$ inches broad, $\frac{3}{8}$ of an inch thick, and 9 feet long?

Ans. 61 lbs.

Set ·375 upon C to ·375 upon D, and opposite $5\frac{1}{4}$ upon C is 4.43 upon D, the mean square. Set 9 upon B to 292 upon A, and opposite 4·43 upon D are 61 lbs. upon C, the answer.

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218. What is the weight of a block of lead 4 inches broad, 1 inch thick, and 32 inches long?

Ans. 52½ lbs.

Set 32 upon B to 243 upon A, the gauge point, and opposite 2 upon D, the mean square, are 52½ lbs. upon C, the answer.

219. What is the weight of a boiler-plate 12 inches square and ¼ thick?

Ans. 10 lbs.

Set 12 upon B to 357 upon A, and opposite 5·45 upon D, the mean square, are 10 lbs. upon C, the answer.

220. What is the weight of a boiler-plate 12 inches square and ⅜ thick?

Ans. 15 lbs

Set ·375 upon C to ·375 upon D, and opposite 12 upon C is 6·70 upon D the mean square. Set 12 upon B to ·357 upon A, and opposite 6·70 upon D are 15 lbs. upon C, the answer.

SOLID METAL BALLS AND CYLINDERS.

Rule. Set the diameter upon B to the gauge point upon A, and opposite the diameter upon D is the weight of the ball upon C.

Rule. For cylinders, set the length upon B to the gauge point upon A, and opposite the diameter upon D is the weight in lbs. upon C.

221. What is the weight of a cast-iron ball 6 inches diameter?

Ans. 29½ lbs.

Set 6 upon B to 733 upon A, and opposite 6 upon D is 29½ lbs. upon C the answer.

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222. What is the weight of a brass ball 7 inches diameter?

Ans. 54 lbs.

Set 7 upon B to 637 upon A, and opposite 7 upon D is 54 lbs. upon C, the answer.

223. A lead ball is 10 inches diameter, required its weight.

Ans. 215 lbs.

Set 10 upon B to 465 upon A, and opposite 10 upon D are 215 lbs. upon C, the answer.

224. What is the weight of a copper ball 3 inches diameter?

Ans. 4½ lbs.

Set 3 upon B to 596 upon A, and opposite 3 upon D is 4½ lbs. upon C, the answer.

225. What is the weight of a governor-ball 9 inches diameter?

Ans. 99·4 lbs.

Set 9 upon B to 733 upon A, and opposite 9 upon D is 99·4 lbs. upon C, the answer.

226. What is the weight of a silver ball 2 inches diameter?

Ans. 1 6 lbs.

Set 2 upon B to 5, the gauge-point, upon A, and opposite 2 upon D are 1·6 lbs. upon C, the answer.

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227. What is the weight of a cast-iron cylinder 2 feet long and 9 inches diameter?

Ans. 397 lbs.

Set 2 upon B to 407 upon A, and opposite 9 upon D are 397 lbs. upon C, the answer.

228. What is the weight of a brass cylinder 12 inches long and 6 inches diameter?

Ans. 102 lbs.

Set 12 upon B to 424 upon A, and opposite 6 upon D are 102 lbs. upon C, the answer.

229 What is the weight of a solid copper roller 4 feet long and 3 inches diameter?

Ans. 108 lbs

Set 4 upon B to 331 upon A, and opposite 3 upon D are 108 lbs. upon C, the answer.

230. What is the weight of a cylindrical piece of lead 39 inches long and 7¼ inches diameter?

Ans. 660 lbs.

Set 39 upon B to 31 upon A, and opposite 7¼ upon D is 660 lbs. upon C, the answer.

THE WEIGHING OF PIPING, SHELLS, ETC.

Rule. Set the length of the pipes upon B to the gauge point upon A, and the difference between the inner and outer diameters will be the weight of the pipe upon C.

For shells or hollow balls, proceed as in the last Rule.

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EXAMPLES.

231. What is the weight of a cast-iron pipe, 9 feet long, 4 inches bore, and $\frac{3}{4}$-inch thick?

Ans. 315 lbs.

Set 9 upon B to 407 upon A the gauge point, and opposite 4 upon D are 315 lbs. upon C, the weight of a solid cylinder 4 inches diameter and 9 feet long. Then twice $\frac{3}{4}$ added to the inner diameter is $5\frac{1}{2}$ inches the outside diameter; allow the slide to remain as above, and opposite $5\frac{1}{2}$ upon D are 670 lbs. upon C. Subtract 355 from 670, and it leaves 315 lbs. for the weight of the pipe.

232. What is the weight of a cast-iron pipe 5 feet long, $5\frac{1}{2}$ inches bore, and $\frac{3}{4}$-inch thick?

Ans. 230 lbs.

Set 5 upon B to 407 upon A, and opposite $5\frac{1}{2}$ upon D is 370 lbs. upon C: then twice $\frac{3}{4}$ added to $5\frac{1}{2}$ is 7 inches for the outside diameter. Opposite 7 upon D are 600 lbs. upon C: subtract 370 from 600, and it leaves 230 lbs. for the weight of the pipe.

233. Required the weight of a brass pipe 3 inches bore, $\frac{1}{2}$-inch thick, and 3 feet long.

Ans. 59 lbs.

Set 3 upon B to 354 upon A, the gauge point, and opposite 3 upon D is 77 lbs. upon C: add twice $\frac{1}{2}$-inch to 3, and the sum is 4 inches for the outside diameter. Opposite 4 upon D is 136 lbs. upon C: substract 77 from 136, and it leaves 59 lbs. for the weight of the pipe.

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234. What is the weight of a copper roller 4 inches bore, 6 feet long, and $\frac{5}{8}$ thick?

Ans. 210 lbs.

Set 6 upon B to 331 upon A, and opposite 4 upon D are 290 lbs. upon C: add twice $\frac{5}{8}$ to 4, and the sum is $5\frac{1}{4}$ for the outside diameter. Opposite $5\frac{1}{4}$ upon D are 500 lbs. upon C: subtract 290 from 500, and it leaves 210 lbs. for the weight of the roller.

235. What is the weight of a bomb-shell 8 inches diameter and $\frac{1}{2}$ inch thick?

Ans. 23 lbs.

Set 8 upon B to ·733 upon A, and opposite 8 upon D are $69\frac{1}{2}$ lbs. upon C: then set 7 upon B to ·733 upon A, and opposite 7 upon D are $46\frac{1}{2}$ lbs. upon C: subtract $46\frac{1}{2}$ from $69\frac{1}{2}$, and it leaves 23 lbs. for the weight of the shell.

236. What is the weight of a copper ball $9\frac{1}{2}$ inches diameter and $\frac{1}{8}$ of an inch thick?

Ans. 12 lbs.

Set $9\frac{1}{2}$ upon B to ·596 upon A, and opposite $9\frac{1}{2}$ upon D is 144 lbs. upon C; then set $9\frac{1}{4}$, the inner diameter, upon B to ·596 upon A, and opposite $9\frac{1}{4}$ upon D, are 132 lbs. upon C: subtract 132 from 144, and it leaves 12 lbs. for the weight of the ball.

LIQUID MEASURE.

To find the quantity of water contained in any given pipes, the length and diameter being given.

Rule. Set the length upon B to the gauge points upon A, and opposite the diameter upon D is the number of gallons upon C.

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EXAMPLES.

237. A column of water is 6 feet long and 10½ inches diameter; required the content in imperial gallons.

Ans. 22½ gallons.

Set 6 upon B to 294 upon A, and opposite 10½ upon D is 22½ gallons upon C, the answer.

238. A column of water is 18 feet high and 12 inches diameter, how many imperial gallons does it contain?

Ans. 88·3 gallons.

Set 18 upon B to 294 upon A, and opposite 12 upon D is 88·3 gallons upon C, the answer.

239. A column of water stands 36 feet high, and is 4 inches in diameter; required the contents in imperial gallons.

Ans. 19·6 gallons.

Set 36 upon B to 294 upon A, and opposite 4 upon D is 19·6 upon C, the answer.

240. If the cold water-pump of a steam-engine be 7½ inches diameter, and the length of the stroke 36 inches, how many imperial gallons will be lifted at each stroke?

Ans. 5·7 gallons.

Set 36 upon B to 353 upon A, the guage-point, and opposite 7½ upon D is 5·7 gallons upon C, the answer.

241. A gallon of water weighs 10 lbs.; required the weight of water in a pipe 3 inches bore and 24 feet long.

Ans. 73·6 lbs.

Set 24 upon B to 294 upon A, and opposite 3 upon D are 7·36 gallons upon C. Multiply by 10, and the product is 73·6 lbs., the answer.

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242. What is the weight of water in a pipe 7 inches bore and 6 feet high? Ans. 100 lbs.

Set 6 upon B to 294 upon A, and opposite 7 upon D are 10 gallons upon C. Multiply by 10, and the product is 100 lbs, the answer.

243. How many gallons per minute will a pump deliver, 9 inches diameter, 3 feet length of the stroke, 24 strokes per minute? Ans. 197 gallons.

Set 72 upon B to 294 upon A, and opposite 9 upon D are 197 gallons upon C, the answer.

244. A stone cistern is 3 feet square and 3 feet deep, how many imperial gallons will it contain?
Ans. 168½ gallons.

Set 3 upon B to 16 upon A the gauge-point, and opposite 3 upon D is 168½ gallons upon C, the answer.

245. How many imperial gallons will a cistern contain, the length being 40 inches, the breadth 24 inches, and the depth 16 inches? Ans. 55½ gallons.

Set 40 upon B to 2773 upon A, and opposite 19·6 upon D, the mean square, is 55½ gallons upon C, the answer.

CASK GAUGING.

In order to perform the difficult part of gauging, the three following dimensions of the cask must be accurately taken, viz.:—

The bung diameter,
The head diameter,
The length of the cask,
} Within the cask.

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By these dimensions many persons will imagine the contents of the cask will be perfectly limited; but it will be easy to conceive that the diameters and length of one cask may be equal to those of another cask, and yet one of those casks may contain several gallons more than the other. Hence it appears that no one general rule can be given by which all sorts of casks can be exactly gauged. And therefore it is necessary to divide them into four forms or varieties. Thus, if the staves of the cask be very much curved, it belongs to the first variety.

If the staves of the cask, between the bung and the head, be something less curved, it belongs to the second variety.

If the staves be very little curved, it is of the third variety.

But if the staves be straight from the bung to the head, it belongs to the fourth variety.

Rule. Multiply the difference between the bung and head diameter by 7 for the first variety, by ·65 for the second variety, by ·6 for the third variety, and by ·5 for the fourth variéty: add the product to the head diameter, and the sum is the mean diameter; and proceed exactly the same as in the last examples.

EXAMPLES.

246. In a cask of the first variety, length 40 inches, bung diameter 32 inches, head diameter 24 inches, how many imperial gallons will it contain?

Ans. 99 gallons.

Here the difference between the bung and head diameters is 8 inches, multiply by ·7 and the product is 5·6,

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added to the head diameter is 29·6 for the mean diameter. Then set 40, the length of the cask, upon B to 353 upon A the gauge-point, and opposite 29·6 upon D is 99 gallons upon C, the answer.

247. In a cask of the second variety, bung diameter 27, head 22, and length 30 inches; required the content of the cask.

Ans. 54 gallons.

Multiply 5 by ·65, the difference between the head and bung diameters, and the product is 3·25, added to the head diameter the sum is 25·25, or 25¼, the mean diameter. Set 30 upon B to 353 upon A, and opposite 25¼ upon D is 54 gallons upon C.

248. How many imperial gallons are contained in a cask of the third variety, head diameter 18, bung 23, and the length 28 inches?

Ans. 35 gallons.

Multiply 5, the difference between the head and bung diameter, by ·6, and the product is 3·0, added to the head diameter the sum is 21, the mean diameter. Set 28 upon B to 353 upon A, and opposite 21 upon D are 35 gallons upon C the answer.

249. How many imperial gallons are contained in a cask of the fourth variety, head diameter 25, bung diameter 33, and the length 40 inches?

Ans. 95 gallons.

Multiply 8, the difference between the head and bung diameters, by ·5, and the product is 4·0. Added to the head diameter, the sum is 29, the mean diameter. Set 40 upon B to 353 upon A, and opposite 29 upon D are 95 gallons upon C, the answer.

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ON THE PITCH OF TEETH IN WHEELS.

CASE 1.

Given the pitch and diameter to find the number of teeth.

Rule. Set the pitch of the tooth upon B to 3·1416 upon A, and opposite the diameter upon B is the number of teeth upon A.

EXAMPLES.

250. How many teeth are there in a wheel $1\frac{1}{4}$ inch pitch, and $22\frac{1}{2}$ inches diameter.

Ans. 40 teeth.

Set $1\frac{1}{4}$ upon B to 3·1416 upon A, and opposite $22\frac{1}{2}$ upon B are 40 teeth upon A, the answer.

251. Required the number of teeth in a wheel $2\frac{3}{4}$ inches pitch, and 42 inches diameter.

Ans. 48 teeth.

Set $2\frac{3}{4}$ upon B to 3·1416 upon A, and opposite 42 upon B are 48 teeth upon A, the answer.

252. How many teeth are there in a wheel $76\frac{1}{2}$ inches diameter and $2\frac{3}{8}$ inches pitch?

Ans. 102 teeth.

Set 2·375 upon B to 3·1416 upon A, and opposite $76\frac{1}{2}$ upon B are 102 teeth upon A, the answer.

253. How many teeth are there in a wheel 83 inches diameter and 4 inches pitch.

Ans. 65 teeth.

Set 4 upon B to 3·1416 upon A, and opposite 83 upon B are 65 teeth upon A, the answer.

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254. How many teeth are there in a wheel 24 inches diameter at the pitch line, and 2½ inches pitch?

Ans. 30 teeth.

Set 2½ upon B to 3·1416 upon A, and opposite 24 upon B are 30 teeth upon A, the answer.

Case 2.

Given the diameter at the pitch line, and the number of teeth, to find the pitch of the tooth.

Rule. Set the diameter upon B to the number of teeth upon A, and opposite 3·1416 upon A is the pitch of the tooth upon B.

EXAMPLES.

255. A wheel 24 inches diameter has 30 teeth, what is the pitch of the teeth?

Ans. 2½ inches.

Set 24 upon B to 30 upon A, and opposite 3·1416 upon A is 2½ inches pitch upon B, the answer.

256. If a wheel is 48¾ inches diameter, and has 136 teeth, what is the pitch of the teeth?

Ans. 1⅛ inches.

Set 48¾ upon B to 136 upon A, and opposite 3·1416 upon A is 1⅛ of an inch pitch upon B, the answer.

257. If a wheel 67 inches diameter has 60 teeth, what is the pitch of the tooth?

Ans. 3½ inches.

Set 67 upon B to 60 upon A, and opposite 3·1416 upon A is 3½ inches pitch upon B, the answer.

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258. If a wheel 64 inches diameter has 160 teeth, what is the pitch of the tooth?

Ans. $1\frac{1}{4}$ inches.

Set 64 upon B to 160 upon A, and opposite 3·1416 upon A is 1·25 equal to $1\frac{1}{4}$ inch upon B, the answer.

259. If a wheel 43 inches diameter contains 60 teeth, what is the pitch?

Ans. $2\frac{1}{4}$ inches.

Set 43 upon B to 60 upon A, and opposite 3·1416 upon A is $2\frac{1}{4}$ upon B, the answer.

260. If a wheel 90 inches diameter contains 174 teeth, what is the pitch?

Ans. $1\frac{5}{8}$ inches.

Set 90 upon B to 174 upon A, and opposite 3·1416 upon A is 1·625 upon B, the answer.

Case 3.

Given the number of teeth and the pitch to find the diameter.

Rule. Set the pitch upon B to 3·1416 upon A, and opposite the number of teeth upon A is the diameter upon B.

EXAMPLES.

261. If a wheel is $1\frac{1}{2}$ inches pitch, and contains 67 teeth, what is the diameter?

Ans. 32 inches.

Set $1\frac{1}{2}$ upon B to 3·1416 upon A, and opposite 67 upon A is 32 inches upon B, the answer.

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262. If a wheel contains 140 teeth, and is $2\frac{1}{4}$ inches pitch, what is the diameter?

Ans. 100 inches.

Set $2\frac{1}{4}$ upon B to 3·1416 upon A, and opposite 140 upon A is 100 inches diameter upon B, the answer.

263. If a wheel is $1\frac{5}{8}$ inches pitch, and contains 174 teeth, what is the diameter?

Ans. 90 inches.

Set $1\frac{5}{8}$ upon B to 3·1416 upon A, and opposite 174 upon A is 90 inches upon B, the answer.

264. If a wheel has 53 teeth, is $1\frac{3}{4}$ inches pitch, what is the diameter?

Ans. $29\frac{1}{2}$ inches.

Set $1\frac{3}{4}$ upon B to 3·1416 upon A, and opposite 53 upon A is $29\frac{1}{2}$ inches upon B the answer.

265. If a wheel is 1 inch pitch, and contains 47 teeth, what is the diameter?

Ans. 15 inches.

Set 1 upon B to 3·1416 upon A, and opposite 47 upon A is 15 inches upon B, the answer.

266. If a wheel is $1\frac{1}{2}$ inches pitch, and contains 160 teeth, what is the diameter at the pitch line?

Ans. 63·6 inches.

Set $1\frac{1}{2}$ upon B to 3·1416 upon A, and opposite 160 upon A is 63·6 inches upon B, the answer.

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Case 4.

Given the thickness of a tooth to find the pitch and length.

Rule. Multiply the thickness of the tooth by 2·1 for the pitch. Multiply the same thickness by 1·2 and the product will be the length.

EXAMPLES.

267. If the thickness of a tooth is $1\frac{1}{2}$ inches, what is the pitch and length?

Ans. 3·15 pitch, 1·8 length.

Set 2·1 upon B to 1 upon A, and opposite $1\frac{1}{2}$ upon A is 3·15 upon B, the pitch. Set 1·2 upon B to 1 upon A, and opposite $1\frac{1}{2}$ upon A is 1·8, length of the tooth, upon B.

268 If a tooth is $1\frac{3}{4}$ inches thick, what is the pitch and length?

Ans. 3·675 pitch, 2·1 length.

Set 2·1 upon B to 1 upon A, and opposite $1\frac{3}{4}$ upon A is 3·675 upon B, the pitch. Set 1·2 upon B to 1 upon A, and opposite $1\frac{3}{4}$ upon A is 2·1 upon B, the length.

MISCELLANEOUS PROBLEMS.

To find the space through which a body will fall in a given time.

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Rule. Set $16\frac{1}{12}$ upon C to 1 or 10 upon D, and opposite any number of seconds upon D is the space in feet which a body will fall through.

EXAMPLES.

269. Through what space will a body fall in 6 seconds?

Ans. 579 feet.

Set $16\frac{1}{12}$ upon C to 1 upon D, and opposite 6 upon D is 579 feet upon C, the answer.

270. Suppose a stone is dropped into a coal pit, and arrives at the bottom in 4 seconds, what is the depth of the pit?

Ans. 257 feet.

Set the slide as in the last example, and opposite 4 upon D is 257 feet upon C, the depth of the pit.

PROBLEM 2.

Given the length of a pendulum to find the number of vibrations per minute. Or given the number of vibrations to find the length of the pendulum.

Rule. Invert the slide and set 39·2 upon B to 60 upon D, and opposite any length of a pendulum upon B is the number of vibrations upon D. Or opposite the number of vibrations upon D is the length of a pendulum upon B.

EXAMPLES.

271. Required the length of a pendulum that will vibrate 50 times per minute?

Ans. $56\frac{1}{4}$ inches

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Invert the slide and set 39·2 upon B to 60 upon D, and opposite 50 upon D is 56½ inches upon B, the answer.

272. How many vibrations will a pendulum make that is 88½ inches long?

Ans. 40 vibrations.

Set 39·2 upon B to 60 upon D, and opposite 88½ upon B is 40 vibrations upon D, the answer.

Problem 3.

Given the diameter of a pump, and the depth in yards to find the diameter of the cylinder.

Rule. Set 1 or 10 upon B to the gauge point A, and opposite the length of a column of water upon C is the diameter of a steam cylinder upon D.

EXAMPLES.

273. What is the diameter of a steam cylinder to work a pump 12 inches diameter and 95 yards deep?

Ans. 50 inches.

Look in the table upon the rule, in a line with a 12-inch pump is 264, the gauge point.

Set 1 upon B to 264 upon A, and opposite 95 upon C is 50 inches upon D, the answer.

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Problem 4.

Given the diameter of the main cylinder to find the diameter of the air-pump.

Rule. Set $7\frac{1}{20}$ upon B to 1 upon A, and opposite the diameter upon A is the diameter of the air-pump upon B.

EXAMPLES.

274. Required the diameter of an air-pump for a steam engine, the cylinder being 17 inches diameter.

Ans. 12 inches.

Set $7\frac{1}{20}$ upon B to 1 upon A, and opposite 17 upon A is 12 inches upon B, the answer.

275. If the cylinder of a steam-engine be 24 inches in diameter, what will be the diameter of the air-pump?

Ans. 16·9 inches.

Set $7\frac{1}{20}$ upon B to 1 upon A, and opposite 24 upon A is 16·9 inches upon B, the answer.

276. Required the diameter of an air-pump to an engine, the cylinder being 43 inches diameter.

Ans. 30·4 inches.

Set $7\frac{1}{20}$ upon B to 10 upon A, and opposite 43 upon A is 30·4 inches upon B, the answer.

Problem 5.

Given the diameter of the cylinder to find the diameter of the governor balls.

Rule. Set 3 upon B to 1 upon A, and opposite any diameter of a cylinder upon A is the diameter of the governor balls upon B.

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EXAMPLES.

277. Required the diameter of the governor balls for a 30-inch cylinder. Ans. 9 inches.

Set 3 upon B to 1 upon A, and opposite 30 upon A is 9 inches upon B, the answer.

278. What is the diameter of the governor balls for a 40-inch cylinder? Ans. 12 inches.

Set 3 up B to 1 upon A, and opposite 40 upon A is 12 upon B, the answer.

Problem 6.

To calculate the nominal power of an engine.

Rule. Set ·357 upon C to 1 or 10 upon D, and opposite any diameter of a cylinder upon D is the number of horse-power upon C, or *vice versa*.

EXAMPLES.

279. What is the power of an engine the cylinder being 75 inches diameter? Ans. 200 horse-power.

Set ·357 upon C to 10 upon D, and opposite 75 upon D is 200 horse-power upon C, the answer.

280. If the diameter of a cylinder is 40 inches, what is the power of the engine? Ans. 57 horse-power.

Set ·357 upon C to 10 upon D, and opposite 40 upon D is 57 horse-power upon C, the answer.

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To find the Drafts of Rollers.

Rule. Invert the slide and set the number of teeth in the back roller wheel upon C to 1 upon A, and opposite the number of teeth in the change-pinion upon C is the number of revolutions the change-pinion will make for the back roller's one. Then set the number of teeth in the stud-wheel upon C to the same revolutions upon A, and opposite the number of teeth in the front roller-pinion upon C will be the speed of the front roller upon A. Then set the diameter of the front roller upon C to its revolutions upon A, and opposite the diameter of the back roller upon C is the draft upon A.

EXAMPLES.

281. The back-roller wheel contains 44 teeth, change-pinion 22, the stud-wheel 35, and the front roller-wheel 20 teeth; diameter of the front roller 1½ inches, back roller 1 inch; required the draft.

Ans. 5¼ draft.

Set 44 upon C to 1 upon A, and opposite 22 upon C is 2 upon A. Then set 35 upon C to 2 upon A, and opposite 20 upon C is 3½ upon A. Then set 1½ upon C to 3½ upon A, and opposite 1 upon C is 5¼ upon A, the draft required.

282. What is the draft of a jack-frame, the back roller-wheel having 48 teeth, change-pinion 32 teeth, stud-wheel 70 teeth, front roller-pinion 21 teeth, diameter of the front roller 1¼ inches, back roller 1 inch diameter.

Ans. 6¼ draft.

Set 48 upon C to 1 upon A, and opposite 32 upon C is 1½ upon A. Then set 70 upon C to 1½ upon A, and

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opposite 21 upon C is 5 upon A. Then set 1¼ upon C to 5 upon A, and opposite 1 upon C the diameter of the back roller is 6¼ upon A the draft.

283. The back roller-wheel contains 60 teeth, change-pinion 24, stud-wheel 120, front roller-pinion 40 teeth, diameter of the front roller 1⅛ inches, back roller ⅞ diameter; required the draft.

9·6 draft.

Set 60 upon C to 1 upon A, and opposite 24 upon C is 2½ upon A. Then set 120 upon C to 2½ upon A, and opposite 40 upon C is 7½ upon A. Then set 9 equal 1⅛ inches upon C to 7½ upon A, and opposite 7 upon C equal ⅞ is 9·6 upon A, the draft.

Note.—If an alteration in the draft is to be made this is the rule:—Find the draft before the alteration and after; then set the second draft upon C to the hanks roving of the first draft upon A, and opposite the first draft upon C is the hank roving produced by the alteration upon A.

284. If a stretching-frame is producing an 8-hank roving, the back roller-wheel 42, change-pinion 35, stud-wheel 120, front roller-pinion 24 teeth, diameter of the front roller 1⅛ inches, back roller ⅞ diameter. Change the 42 to a 54 and 24 for a 34, what hanks roving will be produced by the alteration?

Ans. { First draft..... 7·71.
Second draft..... 7.
Roving produced 7¼.

Set 42 upon C to 1 upon A, and opposite 35 upon C is 1·2 upon A. Then set 120 upon C to 1·2 upon A, and opposite 24 upon C is 6 upon A. Then set 9 upon C to 6 upon A, and opposite ⅞ upon C is 7·71 upon A, the first

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draft. Then set 54 upon C to 1 upon A, and opposite 35 upon C is 1·54 upon A. Then set 120 upon C to 1·54 upon A, and opposite 34 upon C is 5·43 upon A. Then set 1¼ upon C to 5·43 upon A, and opposite ¼ upon C is 7 upon A, the second draft. Then set 7 upon C to 8 the hank roving upon A, and opposite 7·71 upon C is 7¼ upon A, the hank roving produced by the alteration.

Drafts required in Spinning.

Rule. Invert the slide and set the numbers upon C to 10 upon A, and opposite the single roving upon C is a divisor upon A. Then set the length delivered from the rollers upon C to the divisor upon A, and opposite the length of the stretch upon C is the draft required upon A.

EXAMPLES.

285. Required the draft to spin 156's from a 12-hank roving, the rollers to deliver 40 inches, length of the stretch 52 inches.

Ans. 10 draft.

Set 156 upon C to 10 upon A, and opposite 12 upon C is 13 upon A, the divisor. Then set 40 upon C to 13 upon A, and opposite 52 upon C is 10 upon A, the draft.

286. What draft will be required to spin 36's from a 2½-hank roving, 42 inches delivered from the rollers, 62 inches the length of the stretch.

Ans. 9¾ draft.

Set 36 upon C to 1 upon A, and opposite 2½ upon C is 14·4 upon A, the divisor. Then set 42 upon C to 14·4 upon A, and opposite 62 upon C is 9¾ upon A, the draft.

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287. Required the draft to spin 60's from a $4\frac{3}{4}$-hank roving, 43 inches delivered from the rollers, and a 60-inch stretch.

Ans. 9·1 draft.

Set 60 upon C to 1 upon A, and opposite $4\frac{3}{4}$ upon C is 12·7 upon A, the divisor. Then set 43 upon C to 12·7 upon A, and opposite 60 upon C is 9·1 upon A, the draft.

288. If 280's be spun from a 14 single roving, 40 inches delivered from the rollers, 50 inches the length of the stretch, what is the draft?

Ans. 16 draft.

Set 280 upon C to 1 upon A, and opposite 14 upon C is 20 upon A, the divisor. Then set 40 upon C to 20 upon A, and opposite 50 upon C is 16 upon A, the draft.

On the Hanks Roving.

Rule. Invert the slide and set the counts upon C to 1 upon A, and opposite the draft upon C is a divisor upon A. Then set the lengths delivered from the rollers upon C to the divisor upon A, and opposite the length of the stretch upon C is the hanks roving single upon A.

EXAMPLES.

289. I am spinning 190's with 14 draft, 40 inches delivered from the rollers, and a 54-inch stretch; required the single roving.

Ans. 10 single roving.

Set 190 upon C to 1 upon A, and opposite 14 upon C is 13·6 upon A, the divisor. Then set 40 upon C to 13·6 upon A, and opposite 54 upon C is 10 upon A, the single roving.

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290. If 40's be the counts, 12 the draft, 42 inches delivered from the rollers, stretch 56 inches, what hanks roving will be required?

Ans. $2\frac{1}{3}$ hank roving.

Set 40 upon C to 1 upon A, and opposite 12 upon C is 3·33 upon A, the divisor. Then set 42 upon C to 3·33 upon A, and opposite 56 upon C is $2\frac{1}{3}$ hanks roving upon A.

291. If 270's be the counts, 10 the draft, 40 inches delivered from the rollers, stretch 54 inches, what is the hanks roving?

Ans. 20 hanks roving.

Set 270 upon C to 1 upon A, and opposite 10 upon C is 27 upon A, the divisor. Then set 40 upon C to 27 upon A, and opposite 54 upon C is 20 upon A, the hanks roving.

292. If the counts of the yarn are 120's, with a draft of $12\frac{1}{2}$, the delivery from the rollers is $40\frac{1}{2}$ inches, length of the stretch 60 inches, what is the double roving?

Ans. 13 double rovings.

Set 120 upon C to 1 upon A, and opposite $12\frac{1}{2}$ upon C is 9·6 upon A, the divisor. Then set $42\frac{1}{2}$ upon C to 9·6 upon A, and opposite 60 upon C is $6\frac{1}{2}$ upon A, the single roving. Multiply by 2 and the product is 13 the double roving.

On the Counts of Yarn.

Rule. Multiply the hanks roving, and draft together for a divisor. Then set the length delivered from the rollers upon B to the divisor upon A, and opposite the length of the stretch upon B is the counts of yarn upon A.

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EXAMPLES.

293. The hanks roving is 12, draft 13, the length delivered from the rollers 39 inches, 50 inches being the stretch; required the counts of the yarn.

Ans. 200 hanks.

By multiplication, 12 times 13 are 156. Set 39 upon B to 156 upon A, and opposite 50 upon B is 200 upon A, the answer.

294. The hanks roving is 10, the draft 14, the stretch 54, and the length delivered 40 inches; required the counts. Ans. 189 hanks.

By multiplication, 10 times 14 are 140. Set 40 upon B to 140 upon A, and opposite 54 upon B is 189 upon A, the counts of the yarn.

295 The hanks roving is 2½, the draft 12, the stretch 56 inches, the length delivered 42 inches; required the counts of the yarn? Ans. 40 hanks.

By multiplication 12 times 2½ are 30. Set 42 upon B to 30 upon A, and opposite 56 upon B is 40 upon A, the counts of the yarn.

To find the twist per inch of roving or yarn.

Rule. Set 71 upon C to 1 or 10 upon D, and opposite any counts of yarn upon C is the number of turns per inch upon D.

EXAMPLES.

296. If the counts spinning be 49's with 16¼ turns per inch of yarn, how many turns per inch will 64's require?

Ans. 30 turns.

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Set 71 upon C to 10 upon D, and opposite 64 upon C is 30 turns upon D, the answer.

297. What twist is necessary to spin 144's, 256's, and 36's yarn? Ans. 45, 60, and 22½, turns.

Set 71 upon C to 10 upon D, and opposite 144, 256, and 36 upon C is 45, 60, and 22½ turns per inch upon D, the answer.

BLOCK TACKLE.

To find the power to raise a given weight.

Rule. Set the weight to be raised upon B to twice the number of pulleys upon A, and opposite 1 or 10 upon A is the power required upon B.

EXAMPLES.

298. Two blocks having 4 pulleys each, the one fixed and the other moveable, required the power to raise 450 lbs. Ans. 56¼ lbs.

Set 450 upon B to 8 upon A, and opposite 1 upon A is 56¼ lbs. upon B, the power required.

299. Two blocks have 3 pulleys each, the one fixed and the other moveable, required the power to raise 984 lbs. Ans. 164 lbs.

Set 984 upon B to 6 upon A, and opposite 1 upon A is 164 lbs. upon B, the power required.

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To find the weight to be raised.

Rule. Multiply the power by twice the number of moveable pulleys, and the product is the weight to be raised.

EXAMPLE.

300. What weight will a power of 25 lbs. lift applied to a 4-shieved block which is moveable? Ans. 200 lbs.

Multiply 25 by 8 and the product is 200 lbs. the answer.

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